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BURMA

Technical report 5

Geology and Exploration Geochemistry of the Salingyi-Shinmataung Area, Central Burma

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NOTES

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<u>The following abbreviations have been used</u>:

DGSE - Department of Geological Survey and Mineral Exploration (Burma)

K - kyats, K 6.72 = $US 1 in February 1979

m.y. - million years

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ABSTRACT

The Salingyi-Shinmataung Area is a north-trending belt of 1,980 sq km lying within the Burma Volcanic Arc between 12 and 80 km south of the porphyry copper deposits at Monywa. Geological mapping and reconnaissance geochemical exploration were carried out between October 1975 and January 1976 and in December 1977 and January 1978. The stratigraphy and structure of the area and the ages of the main plutons were determined. A 1:100,000 scale geological map for colour printing was produced.

During geochemical reconnaissance 691 stream sediments samples were collected and each analysed for copper, lead and zinc. Although the area includes small inliers of igneous rocks of the Burma Volcanic Arc, which further north are mineralised, only low geochemical anomalies were found and follow-up work is not recommended.

The geological mapping results show that at Salingyi a complex of metamorphic and igneous rocks comprising pre-Late Mesozoic gneiss and amphibolite is intruded by gabbro, diorite and granite; the three types of pluton each yielded a mid-Cretaceous radiometric age. At Shinmataung conglomerates and boulder beds overlying pillow lavas are of inferred Upper Cretaceous to Lowermost Tertiary age, and are overlain by Oligocene red beds and younger sedimentary rocks. The geological results support the evidence from the Pinlebu-Banmauk Area that the Burma Volcanic Arc developed across older metamorphic "basement" in the Lower Cretaceous.

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INTRODUCTION

Background

The Mineral and Exploration Project (BUR-72-002), with the United Nations the Executing Agency, became operational in January 1974. The Government Counterpart Agency was the Department of Geological Survey and Mineral Exploration (DGSE) of the Ministry of Mines.

The total UNDP contribution according to the revised budget was estimated at $US 1,888,752, the Government's contribution was K 5,120,600, partly in cash and partly in kind. The latest Project revision extended the Project until late June 1978.

The main objective of the Project was to carry out systematic regional geochemical exploration and geological mapping of selected areas followed by detailed investigations in areas of special interest. Since 1974 approximately 17,900 square miles (46,500 sq km) have been surveyed by the Project.

This Report and accompanying geological map (Map 1) describe the results of geological mapping and reconnaissance geochemical exploration in the Salingyi-Shinmataung Area of central Burma. The area comprises three 1 inch to 1 mile scale map sheets, 84 0/1, 84 0/2 and 84 0/3, each of approximately 660 sq km, bounded by latitude 21°15' and 22°N and longitude 95°N' and 95°15'E (Fig. 1). These boundaries were selected to include known and inferred areas of igneous rock within the Volcanic Arc south of the Monywa porphyry copper deposits, which occur within Late Cenozoic volcanic rocks.

Communications, settlement and climate

Salingyi township lies within the administrative district of Sagaing, and Pakokku township within that of Magwe. The Chindwin and Irrawaddy rivers which flow through the eastern part of the area are navigable for large vessels throughout the year. An all-season motor road extends from Pakokku, the large town on the west bank of the Irrawaddy in the south of the area, to Salingyi near the Chindwin in the north; the road continues northwards to Monywa where it is connected by river ferry to the Mandalay-Monywa motor road. Few of the numerous cart tracks within the area are open to four-wheel drive vehicles throughout the year. There is also a close network of footpaths.

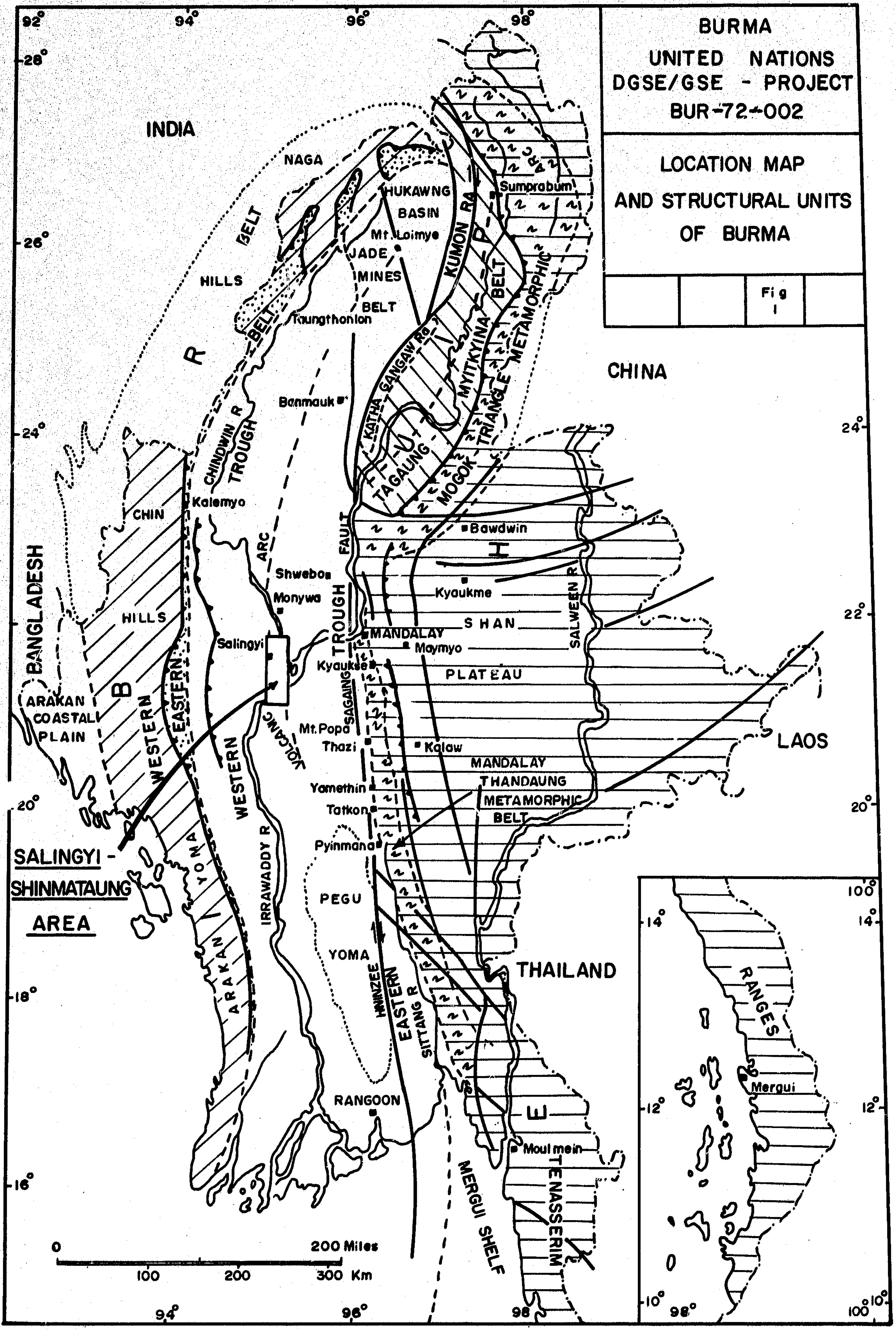
The Irrawaddy-Chindwin alluvial valley and adjacent plain are densely populated with numerous villages but there are no villages on the uplands. Most of the population is engaged in farming and except in the uplands the area is intensively cultivated.

There are no meteorological observations of records within the area, which lies in the semi-arid zone of Burma. The estimated annual rainfall of 25-40 inches mostly falls between June and September. A marked hot season lasts from February to May with daily maximum temperatures up to 110° F, and a relatively cool season extends from October to January.

Physiography

The area includes the broad alluvial valleys and river channels of the southeast-flowing Chindwin river in the northeast and the southwest-flowing Irrawaddy in the southeast; the confluence of the two rivers lies immediately east of sheet 0/2. The alluvial valley and river channels, at an elevation of about 220 ft, occupy nearly half the area (Fig. 2).

West of the Irrawaddy and Chindwin, gently undulating lowlands underlain by Late Cenozoic sedimentary rocks rise slightly towards the Shinmataung and Salingyi Uplands; stream courses are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LOCATION MAP
AND STRUCTURAL UNITS
OF BURMA
Fig
1
INDIA
CHINA
BANGLADESH
LAOS
THAILAND
SALINGYI - SHINMATAUNG AREA
ARAKAN COASTAL PLAIN
NAGA HILLS BELT
CHIN HILLS
INDO-BURMAN RANGES
WESTERN
EASTERN
ARAKAN YOMA
WESTERN TROUGH
CHINDWIN R
VOLCANIC ARC
IRRAWADDY R
HUKAWNG BASIN
JADE MINES BELT
KUMON RA
KATHA GANGAW Ra
MYITKYINA BELT
TAGAUNG
MOGOK TRIANGLE
METAMORPHIC ARC
SAGAING FAULT
SAGAING TROUGH
SHAN PLATEAU
MANDALAY THANDAUNG METAMORPHIC BELT
SALWEEN R
PEGU YOMA
HWINZEE
EASTERN
SITTANG R
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TENASSERIM
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Mt. Loimye
Taungthonlon
Banmauk
Kalemyo
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MANDALAY
Maymyo
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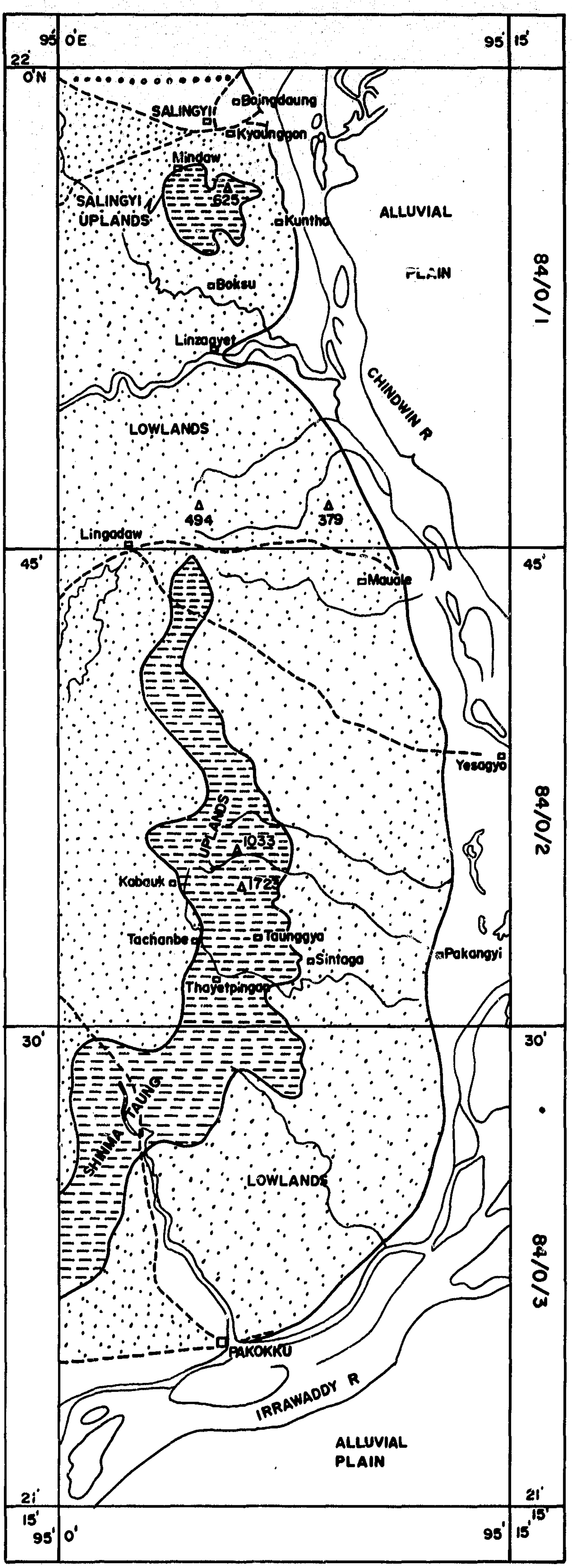

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SALINGYI-SHINMATAUNG AREA

PHYSIOGRAPHY

short and show a dendritic to subparallel drainage pattern. The lowlands extend westwards between the Salingyi hills in the north and the Shinmataung hills in the south and occupy the westernmost part of the area, where drainage is to the west; soil is mostly thick but there are local swampy areas and near the uplands lateritic red soil is locally present. Silicified wood fragments are scattered over much of the surface of the lowlands and at one locality a felled tree trunk has been silicified (see Plate 5, p. 29).

The Salingyi Uplands are undulating hills with an area of about 110 sq km and maximum elevation of 625 ft. The Shinmataung Uplands form an irregular south-trending ridge mostly above 700 ft in elevation, the upper parts of which are underlain by red sandstone; the highest point is Shinmataung at 1,723 ft. Soil cover is thin on much of the basic rocks of the Salingyi Uplands, and also on the Shinmataung hills, particularly on areas underlain by conglomerates and red sandstone. There is no soil cover on much of the Sontaung basalt.

Previous work

Partly no doubt because of its accessibility, long dry season, and proximity to the oil fields, numerous geological investigations have been made in the Salingyi-Shinmataung Area, but few results have been published.

The earliest recorded investigation was undertaken in 1908 by geologists of the Burma Oil Co. and Geological Survey of India. Fossils from the Shinmataung area were collected and described by Vrenenburg (1922). The Salingyi area was included in a report by Pinfold et al. (1927), who recognized diorite and amphibolite which they considered to be intrusive into the 'Pegu' sandstones. It also lies within the area described by Lepper (1933).

Barber (1936) produced the only published geological map of the area, on a 1 inch to 2 miles scale, accompanied by a detailed geological report and based on field work carried out during 1925-26. In the Salingyi Uplands Barber described a major gabbro body, occupying much of the area, hornblende-granulite intrusives in the northeast, and keratophyres or silicic epidote-bearing porphyritic rocks, in the west. In the Shinmataung Uplands he mapped andesite tuff and basalt flows, all lying west of Shinmataung Peak. All igneous rocks were considered to be of Tertiary age. Barber divided the sedimentary rocks into an extensive Pegu Series of Oligocene-Miocene age which he considered to be intruded by the granulites and gabbros, and the Irrawaddy Series occurring only in the east of the area, of Miocene-Pliocene age.

More recently, an electrical resistivity survey of about 20 sq km in the Baingdaung Area, Salingyi Township, was carried out by staff of the Mineral Development Corp. (Ba Saw Khin 1965). Granite, diorite and dacite, all of inferred Tertiary age were described and sandstones of probable Pliocene age were mentioned.

A report on the sedimentary rocks of the area was included in a description of the Shinmataung-Powintaung region by staff of the Peoples Oil Industry (Than Tun, Mya Aye and Hla Maung, 1968). They described the Pegu and Irrawaddian Series of Barber (1936).

The Salingyi Uplands were mapped in 1971/72 by Dr. Kyaw Kyaw, U Kyaw Win and students of the Geological Department, Mandalay Arts and Science University, but no report is available; in 1974-75 the same area was mapped by DGSE staff (Zaw Pe, San Myint 3, Maung Tint, Myo Myint Swe and Ye Myint Thein, unpub. report 1975). The DGSE mapping provided a useful preliminary map which formed the basis for further work carried out by the Project.

I. OPERATIONS

A. Camps, transport and personnel

Two base camps were established, one in Salingyi and one in Pakokku township. Two geologists were based in the former and four in the latter. Field work extended from Early October 1975 to mid-January 1976. Minor camps were set up in village houses and monasteries, most village being accessible to motor vehicles. Two 4-wheel drive vehicles were provided, and labourers and guides were hired locally.

Additional mapping in the Shinmataung area was carried out by five geologists in December 1977 when air photographs became available for use in the field.

B. Geological mapping

In both field parties a mapping geologist was responsible for co-ordinating geological mapping and defining rock units. All geologists carried out geological mapping which in the upland areas and parts of the adjacent lowlands was combined with stream sediment geochemical sample collecting. The Chief Geologist and Counterpart carried out check traverses in the Salingyi and Shinmataung Uplands. Traverses were made on foot, mostly along paths and on paced compass bearings in the upland areas, and along stream courses elsewhere. Exposures were good in the uplands but very poor in the lower parts of the lowlands.

Field data were plotted on 1 inch to 1 mile scale drainage maps prepared from the topographic sheets. A photogeological interpretation was prepared in Rangoon before the start of field work, and air photographs (1:20,000 scale) were used in the field during brief field work in December 1977.

A geological map on 1 inch to 1 mile scale was drawn by Project draftsmen under the direction of the geologists, and photographically reduced to 1:100,000 scale. This reduced scale map was then traced to form the final map.

Thin sections of 50 rock samples were prepared in the DGSE laboratory. Descriptions of the thin sections were made initially by laboratory staff and in some cases by mapping geologists, and checked by the Chief Geologist. Rock samples and thin sections are stored in the DGSE office in Rangoon.

C. Reconnaissance geochemical sampling

Stream sediment geochemical samples were collected mostly by traverse and supervising geologists, the position of their traverses being determined by the sampling programme. Mapping geologists also collected samples where convenient and in inaccessible areas. Details are given in Chapter VII.

D. Report preparation

A draft geological report was prepared in Rangoon between June and October 1976. The draft was modified considerably following the short period of field work utilising air photographs in December 1977, and rewritten by the Chief Geologist as this Technical Report between January and March 1978.

II. REGIONAL GEOLOGICAL SETTING

The map area lies on and near the southern end of the Burma Volcanic Arc, defined by the occurrence within an arcuate belt of Miocene to Quaternary volcanic rocks. The arc extends northwards from Mt. Popa, the southernmost Late Cenozic eruptive centre in Burma, 50 km south of Pakokku, through the basalt lavas of Shinmataung within the area described here, the andesitic lavas and pyroclastics of Monywa and the basaltic craters to the north, to the large Quaternary strato-volcano of Taungthonlon, 350 km to the north-northeast of Salingyi.

Within the same arcuate belt as the Late Cenozoic volcanoes, volcanic, plutonic and metamorphic rocks, mostly of pre-Tertiary age, form a massif in the Pinlebu-Banmauk area south of Taungthonlon (Technical Report No. 2), occur as pre-Oligocene 'basement' east of Monywa, and underlie the Salingyi Uplands and small areas in the Shinmataung Range within the map area. South of Mt. Popa the Pegu Hills, comprising folded sedimentary rocks of Oligocene to Miocene age, extend southwards towards Rangoon along the projected trend of the Volcanic Arc.

West of the area the Western Trough of the Central Lowlands trends parallel to, and extends south of, the Volcanic Arc. The broadly synclinal Trough succession comprises Albian limestones and serpentinite sills in the west overlain by a very thick Upper Cretaceous to Eocene succession of folded clastic sediments, and by Oligocene and younger sediments which extend eastwards across the Volcanic Arc to the Eastern Trough. The Western Trough succession in the west overlies rocks of the Eastern Belt of the Indoburman Ranges (Technical Report No. 4), comprising local pillow lavas and a thick highly tectonised mostly flysch-type sedimentary succession of Upper Triassic age with associated metamorphic rocks and serpentinites.

East of the area, the Eastern Trough of the Central Lowlands, underlain by post-Eocene sediments, is bordered in the east, and locally cut, by the Hninzee-Sagaing Fault, a major north-trending dextral fault which extends from west of the Gulf of Martaban through northern Burma. The fault forms the western boundary of the Eastern Highlands which comprise the Upper Irrawaddy Province, the Shan States, and Tenasserim. The Shan States are underlain by a very thick Precambrian to Middle-Triassic succession, which in the west is metamorphosed and intruded by Late Mesozoic to Early Tertiary granites. A predominantly clastic succession of Upper Triassic to Upper Jurassic age lies unconformably on older rocks and is overlain unconformably by Cretaceous volcanic rocks, limestones and red beds.

The Salingyi-Shinmataung Area was of particular interest for exploration because it includes inliers of igneous rock within the same belt as mineralized igneous rock at Shangalon (Technical Report No. 1) and at Monywa.

III. GEOLOGY OF THE SALINGYI COMPLEX

The Salingyi Uplands are underlain by a complex of igneous and metamorphic rocks mostly and probably entirely of pre-Tertiary age, with an area of about 110 sq km. The rocks comprising the complex are described below, in probable order of decreasing age (Fig. 3).

A. Tawgyaung gneiss

Gneiss and schist, forming what is considered to be the oldest rock unit in the area, occupy less than half a square kilometre to the north of the Salingyi Uplands, and occur as xenoliths in the Kyaunggon diorite, one kilometre to the south.

Outcrops are mostly highly weathered but biotite schists and banded gneiss can be recognized. The rock shows well-developed joints mostly filled with travertine. The gneiss is probably of higher metamorphic grade and hence older than the adjacent greenschist facies amphibolites described below, but the contact of the two units is not exposed.

The limited area of outcrop of the gneiss and its occurrence as xenoliths in the Kyaunggon diorite suggests that it is a roof pendant in the diorite.

B. Salingyi amphibolite schist

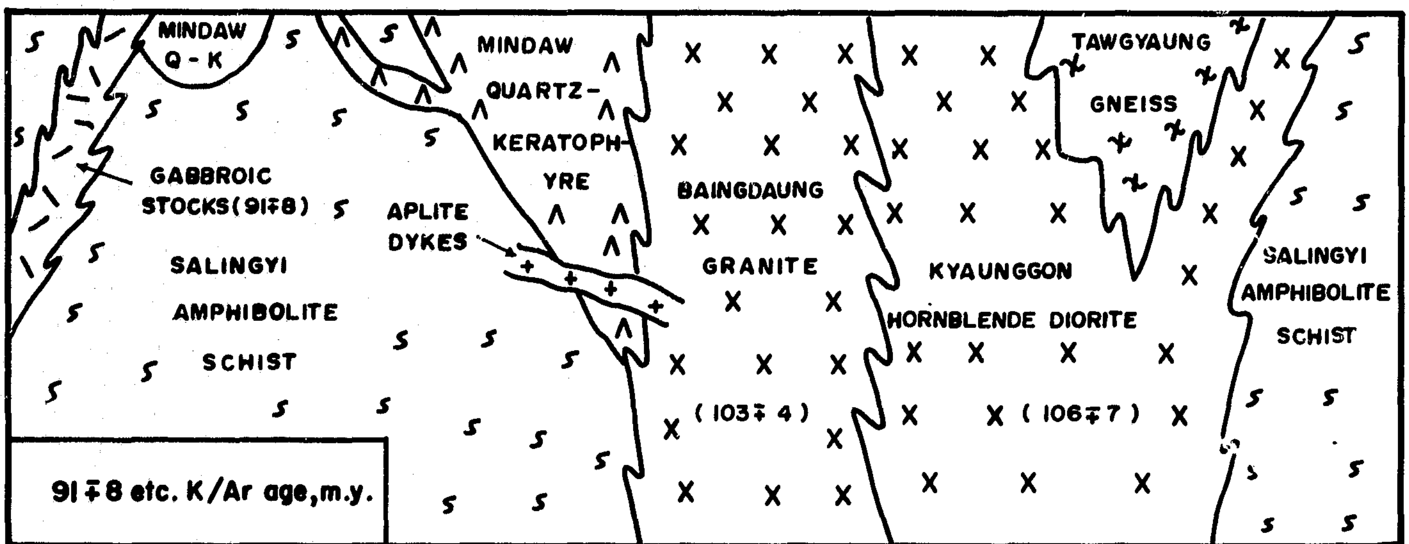
This unit occupies most of the Salingyi Uplands, forming rolling hills covered in grass or scrub from which low knolls and ridges locally protrude. The outcrop area corresponds broadly to that of the gabbro and hornblende granulite of Barber (1936). No estimate of stratigraphic thickness could be made and there is no evidence for the structure of the schist.

Fine-grained and less commonly medium-grained amphibolitic rocks occupy more than 90 per cent of the area underlain by the Salingyi amphibolite schist; they are well exposed for example near 0/1 460 628. The schist is a characteristically black or dark grey massive rock lacking large scale compositional banding and consisting in hand specimen almost entirely of black amphibole lathes or prisms and of plagioclase. The predominant texture is massive but some samples show a faint foliation.

In thin section the rock consists of from 30 per cent to 60 per cent amphibole, commonly of green hornblende but in some samples of hornblende and actinolite or tremolite and rarely entirely of actinolite or tremolite. The amphiboles vary from subhadral prisms to anhedral crystals with ragged margins, mostly showing a preferred orientation of long axes. The other major constituent is plagioclase and minor amounts of iron ore are present. In some samples showing a foliation in hand specimen there is also a weak compositional banding.

The high proportion of amphibole, presence of actinolite or tremolite in some samples, ragged margins to amphiboles, and local foliation suggest that the rock is metamorphic although some specimens show textures resembling those of igneous rocks. The rock was probably formed by greenschist facies metamorphism of gabbro or basalt.

The schist is intruded by plutons of granite and diorite and by small gabbroic bodies, and by epidotised silicic dyke-like bodies. Similar large bodies of amphibolitic schist have not been reported from elsewhere in Burma. However, small areas of amphibolite schist occur in the Hkweka and Yezago metamorphis of Upper Triassic age or older along the eastern margin of the Chin Hills (Technical Report No. 4). The Salingyi amphibolite schists are probably older than the Taungni basalt in the Shinmataung area, because conglomerates overlying the basalt contain large, presumably near-source, boulders of both basalt and amphibolite.



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RELATIONSHIP OF ROCK TYPES , SALINGYI COMPLEX

Fig . 3

C. Gabbroic intrusions

More than 20 small bodies of coarse and medium-grained mafic rocks forming resistant masses have been mapped within the Salingyi amphibolitic schist, of which the larger ones are shown on the geological map (Map 1). They are particularly common in the north of the schist; few are more than 300 m in length and most are elongate with a north-westerly trend, forming low knolls or ridges protruding from the undulating upland surface.

The rocks mostly consist of larger felspar phenocrysts scattered in a fine-grained dark green to black massive to foliated matrix, but some consist largely of hornblende crystals up to 2 cm long. Thin sections show in some samples plagioclase phenocrysts in a groundmass of actinolite laths, and in other up to 70 per cent hornblende with finer-grained plagioclase. Most of the bodies are more mafic than the Kyaunggon hornblende diorite, although they may be satellite plutons of the diorite.

The gabbroic bodies probably intrude the adjacent Salingyi amphibolite schist, although clear contacts between the two units have not been observed; the gabbros lying west of Kuntha show complex contact relationships with the adjacent granite.

A K/Ar radiometric age determination on hornblende from a coarse-grained mafic body yielded an age of 91 ± 8 m.y. (Table 1). This indicates a probable mid-Cretaceous minimum age of either intrusion or metamorphism.

D. Kyaunggon hornblende diorite

Dark-coloured dioritic rocks occupy about 10 sq km in, and north of, the northeastern part of the Salingyi uplands, between the Salingyi amphibolite schist to the south and the conglomerates correlated with the Ingintaung Formation to the north; this area is included in the gabbro and hornblende granulite unit of Barber (1936).

The contact with the amphibolitic schist is not well exposed but relationships with the Baingdaung granite body east of Salingyi town suggest that the granite intrudes the diorite. Thin dykes of granite and microgranite up to 30 cm thick and mostly trending NE occur within the diorite in the west. In the north the diorite is overlain unconformably by conglomerates of the Ingintaung Formation; south of this contact xenoliths of gneiss are present within the diorite.

In hand specimen the rock ranges from medium to coarse-grained and is mostly dark grey but locally pale grey in colour. Some areas of fine-grained diorite also occur. Thin sections show hornblende and plagioclase as essential minerals.

A medium-grained sample of diorite yielded a K/Ar age on hornblende of 106 ± 7 m.y., or latest Lower Cretaceous.

E. Mindaw quartz-keratophyre

White to pale grey, pinkish or rarely greenish rocks occupy an area of about 2.5 sq km on the northwestern margin of the Salingyi Complex east of Mindaw village. They were termed keratophyres by Barber (1936), but contain abundant quartz, and in the absence of a more satisfactory name they are here referred to as quartz-keratophyres based on the terminology of Williams, Turner and Gilbert. Similar rocks occur as small bodies within the amphibolite schist. The rock is mostly well-jointed and locally coated along joints with a layer of recent carbonate. Yellow-green silicic rocks, probably in the form of small dykes, are associated with the small bodies and also occur locally at the margin of the main unit.

East of Mindaw the large body of quartz-keratophyre is overlain unconformably by the Thayetpingan Formation; the contact with amphibolite schist and granite is not exposed. The small bodies of quartz-keratophyre show sharp contacts with the schist.

In hand specimen flow texture is rarely visible and the rocks range from aphanitic to porphyritic or sparsely porphyritic with phenocrysts of felspar, quartz, or both, and scattered mafics; a few show long prisms of felspar in a dark grey groundmass. Pyrite is commonly present and at two localities a speck of chalcopyrite was observed. The yellow-green rocks are mostly aphyric and rarely plagiophyric.

Thin sections of quartz-keratophyre show phenocrysts including orthoclase, plagioclase, quartz, scattered altered mafics, amphiboles and epidote in a silicic groundmass. The aphyric rocks

Table 1. Radiometric age determi

Sample No./ Grid Ref.	Location	Rock type	
8401 490 605	Salingyi Complex	Biotite granite stock Baindaung granite	Bi ho 20
8401 451 654	Salingyi Complex	Mafic hornblende-gabbro	ho
8401 464 664	Salingyi Complex	Hornblende felspar pluton. [illegible]aunggon hornble[illegible] diorite	ho

etric age determinations

	Mineral dated (K/Ar)	Age m.y.
e stock ite	Biotite 80 per cent hornblende and others 20 per cent	103 $\mp$ 4
de-gabbro	hornblende	91 $\mp$ 8
spar ggon rite	hornblende	106 $\mp$ 7

consist of a mosaic of myrmekitic felspar-quartz intergrowths with minor anhedral quartz, clay and chlorite patches, rare amphibole and a trace of opaques. Rocks with conspicuous felspar lathes show corroded orthoclase surrounded by haloes of quartz with minor plagioclase and epidote and interstitial chlorite. The green rocks show a weak foliation, and resemble epidosites, with patches and veins of epidote and rare felspar in a fine-grained quartz mosaic groundmass.

The composition and distribution of the quartz-keratophyre indicate that it probably comprises metamorphosed rhyolitic to microgranitic minor intrusions.

F. Baingdaung granite

Three main granitic plutons with a total area of about 5 sq km occur in the Salingyi Uplands, within, but near the margins of, the Salingyi amphibolite schist. The granite, which comprises the Baingdaung, Boksu and Kuntha plutons, is named for the village of Baingdaung which lies immediately west of the northern pluton. The granites were not described by Barber (1936).

The northern or Baingdaung pluton, exposed along the northeastern margin of the Salingyi Uplands, intrudes the amphibolite schist and probably the Kyaunggon hornblende diorite and is intruded by dacitic and microgranite dykes which mostly trend NE. It is a white to pink biotite granite with a varying proportion of biotite. Near the contact with the diorite garnet is present and the rock is weakly foliated. Mafic xenoliths of either hornblende diorite or amphibolite occur near Ywathit village and near the southern margin of the pluton a zone of 'mixed rocks' with abundant dykes of granite within schist is present.

The southern or Boksu pluton intrudes the amphibolite schist but is well exposed only near the summit of a low hill. It consists of coarse-grained biotite granite and leucogranite.

The eastern or Kuntha pluton intrudes the amphibolite schist and probably gabbroic dykes, and is intruded by aplitic dykes. It is a pale greenish-grey to white biotite-hornblende and hornblende-biotite granite and adamellite. Small xenoliths of fine-grained gabbro occur locally.

A K/Ar ratiometric determination on a biotite concentrate from a sample of the granite (Table 1) yielded an age of 103 $\pm$ 4 m.y., indicating a probable age of intrusion of late Lower Cretacous.

G. Aplitic dykes

Dykes of microgranite and aplite, and very rarely of pegmatite, form small hills and ridges in the amphibolitic schist north of the Kuntha granite pluton. Near the pluton, aplite margins occur on biotite granite dykes within the schist. The aplite here is greenish in colour and where weathered is surrounded by pebbles of epidote-silica rock, suggesting that the quartz-epidote dykes described above are closely related to the microgranite and aplite dykes.

IV. GEOLOGY OF THE SHINMATAUNG BASEMENT

The term Shinmataung Basement is used to include the igneous and metamorphic rocks of unknown age which underlie the sedimentary successions of inferred Upper Cretaceous to Eocene age and younger. The Taungni basalt is the only exposed rock unit of the Basement, but the presence of older metamorphic rocks is inferred from the clasts in the Ingintaung Formation.

A. Metamorphic rocks

Metamorphic rocks are not exposed at Shinmataung. However, the oldest sedimentary rocks, comprising conglomerates and boulder beds within the Ingintaung Formation, contain rounded fragments up to boulder size of a variety of rocks described below (Chapter V, Section A), indicating the varied nature of the nearby buried basement. Among these clasts, amphibolites, gabbros and rare gneiss resemble rocks of the Salingyi Complex, and basaltic clasts resemble the Taungni Basalt. Rare boulders of pegmatite are possibly derived from dykes similar to those at Salingyi.

Rocks broadly similar to the boulders of garnet-mica-schist, quartzite and phyllite occur as roof pendants in the Pinlebu-Banmauk area of the Volcanic Arc to the north, but are not known from elsewhere west of the Hninzee-Sagaing Fault. The boulders resemble the schists and phyllites within the metamorphic belt east of the Fault between Thazi and Pyinmana, which are probably mostly of late Precambrian to Permian age (Technical Report No. 3).

The metamorphic basement at Shinmataung therefore probably includes two contrasting rock associations: amphibolites similar to those at Salingyi, and schists, quartzites and phyllites similar to those east of the Hninzee-Sagaing Fault.

B. Taungni basalt and diorite

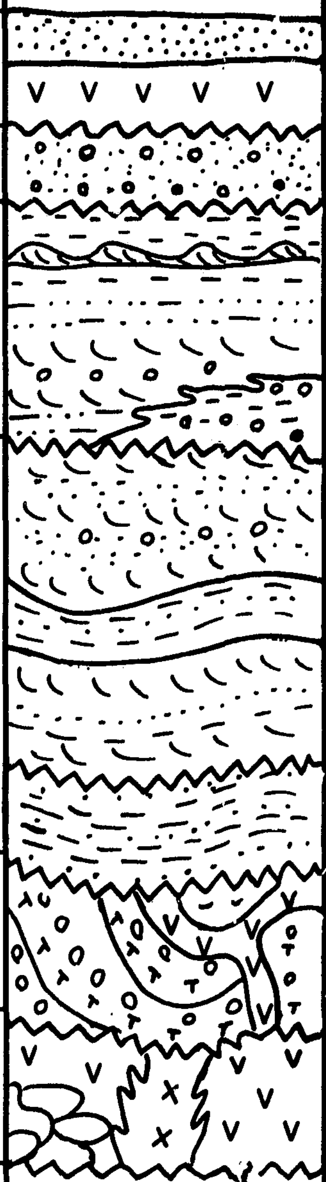
Basaltic rocks with minor diorite are exposed in 5 inliers in the east of the Shinmataung Range; four inliers are only 100 m or so in length but the longest inlier southeast of the locally named Taungni Hill has an area of about half a square kilometre, occupying the lower slopes of a small valley system in which the rock is locally well exposed (Fig. 4).

Exposures are weathered to a characteristic greenish-black or greenish-yellow soft rock, similar in appearance to part of the Mawgyi andesite in the Pinlebu-Banmauk area 270 km to the north. The rock is mostly fine-grained to aphanitic and amygdaloidal, locally with thin calcite veins. In most exposures no structure is visible but at one locality (0/2 447 177) an exposure in a cart track shows weathered pillow lavas up to 30 cm diameter with radial joints and a poorly defined concentric distribution of amygdales. Possible pillow lavas were also noted to the northeast (0/2 429 191).

In thin section the pillow lava shows microphenocrysts of olivine and clinopyroxene, with scattered phenocrysts and skeletal microphenocrysts of plagioclase, in an indeterminate groundmass with calcite patches and possible relict variolitic texture. Abundant small amygdales are of chlorite, epidote, calcite and quartz.

Within the outcrops of predominantly fine-grained rock are areas of fine to locally medium-grained hornblende diorite or gabbro. These appear to be irregular bodies, presumably intrusive into the basalt.

The Taungni basalt is overlain by the Shinmataung sandstone which is not younger than Oligocene, and is older than the Ingintaung Formation in which boulders of basalt and diorite are

AGE		STRATIGRAPHIC UNIT AND THICKNESS (M)	DESCRIPTION
			
		ALLUVIUM	
QUATERNARY		SONTAUNG BASALT >100m	Blocky basalt lava.
? PLIOCENE		KANTHIT GRAVELS >50m	Gently dipping gravel, cong, sst, clay.
MIOCENE TO OLIGOCENE		SINTAGA FM 900m	Mudst and siltst Interbedded ripple cross-lam sst and mudst., thin parallel bedded ssts., cross-bedded to massive concretionary thick ssts., intraform congloms
		TACHANBE CONGLOMERATE	Shales and thin pebbly congloms.
MOSTLY LOWER OLIGOCENE		SHINMATAUNG RED SST. (SHINMATAUNG FM. 1200 m)	Crors-bedded red sst., minor sh., rare pebble cong.
		TAUNGGYA SH. (SHINMATAUNG FM.)	Ripple cross laminated red sst. and yellow siltst
		SUYITTAUNG SST. (SHINMATAUNG FM.)	Red to white quartzose, cross-bedded sst., minor siltst
		THAYETPINGAN SST. AND SH. (SHINMATAUNG FM.)	Green to grey thick concretionary sst., rippled laminated sst. and siltst.
? LOWER EOCENE TO UPPER CRETACEOUS		INGINTAUNG FM >150m	Pilymict congloms., boulder beds, andesitic tuff, minor rhyolite, andesitic dykes, flows or sills.
? LOWER CRETACEOUS		TAUNGNI BASALT AND GABBRO >50m	Chloritic basaltic lavas, pillow lavas, gabbroic intrusions.
? PRE - JURASSIC		BASEMENT NOT EXPOSED.	Schist, quartzite, amphibolite, pegmatite indicated by clasts in Ingintaung Fm.

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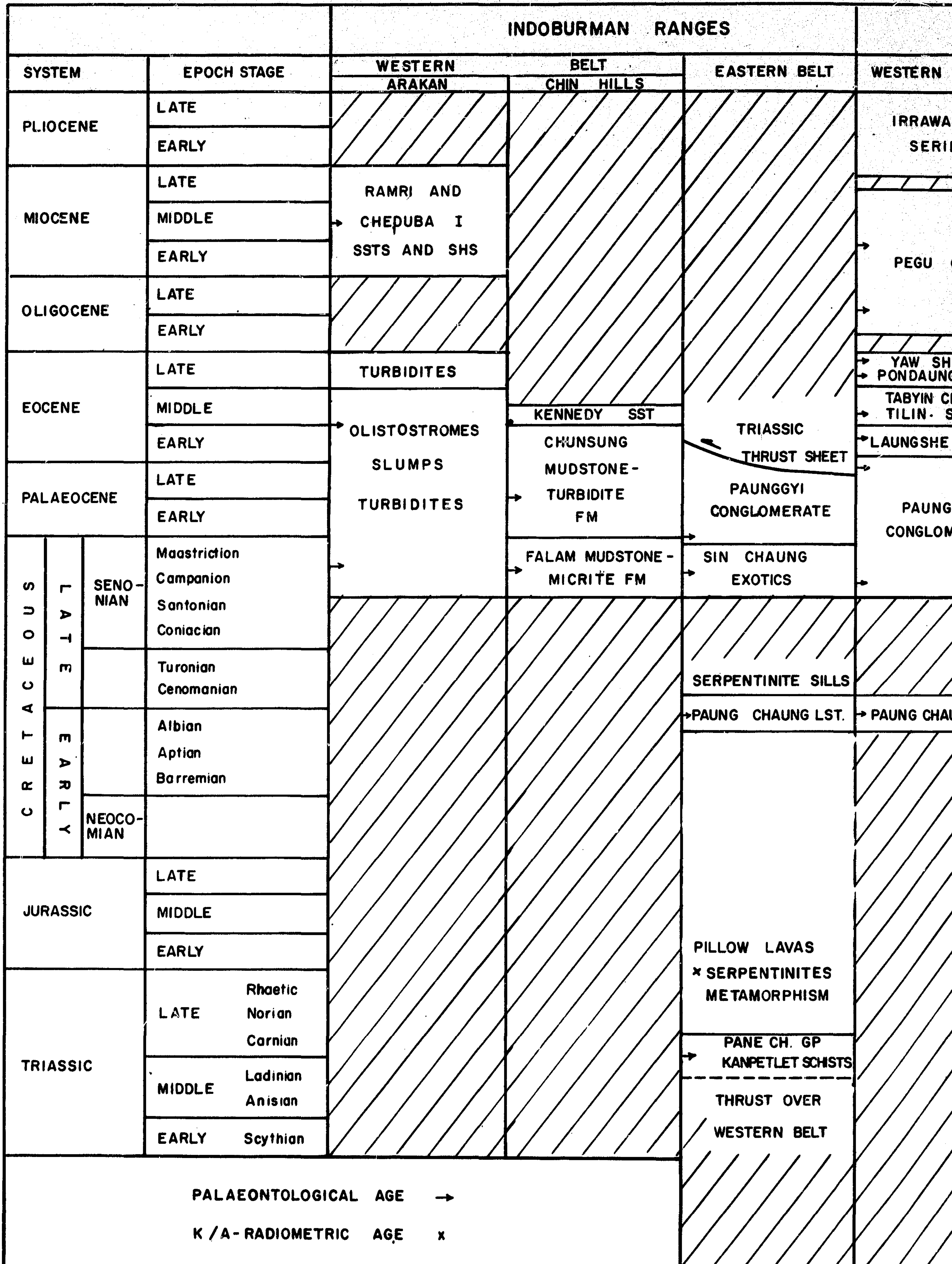
SCHEMATIC STRATIGRAPHIC COLUMN, SHINMATAUNG UPLANDS

Fig - 4

common. The basalt can possibly be correlated (Table 2) with the Mawgyi Andesite of pre-Upper Cretaceous age in the Pinlebu-Banmauk area (Technical Report No. 2); alternatively it may be equivalent to pillow basalts of post-Carnian pre-Albian age in the Chin Hills, 120 km to the west.



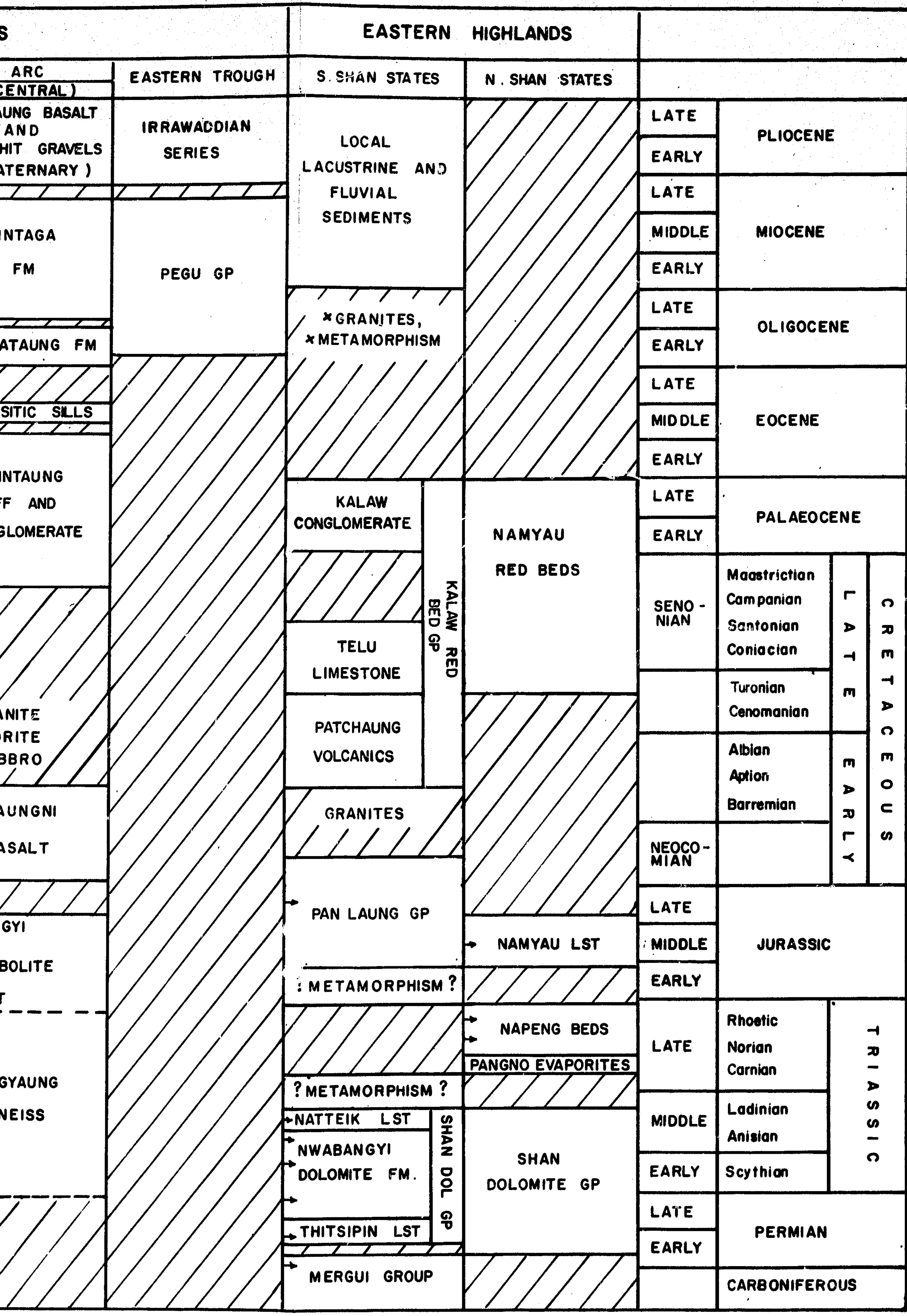
INDOBURMAN RANGES
SYSTEM
EPOCH STAGE
WESTERN BELT
ARAKAN
CHIN HILLS
EASTERN BELT
WESTERN T
PLIOCENE
LATE
EARLY
MIOCENE
LATE
MIDDLE
EARLY
OLIGOCENE
LATE
EARLY
EOCENE
LATE
MIDDLE
EARLY
PALAEOCENE
LATE
EARLY
CRETACEOUS
LATE
SENO-NIAN
Maastriction
Campanion
Santonian
Coniacian
Turonian
Cenomanian
EARLY
Albian
Aptian
Barremian
NEOCO-MIAN
JURASSIC
LATE
MIDDLE
EARLY
TRIASSIC
LATE
Rhaetic
Norian
Carnian
MIDDLE
Ladinian
Anisian
EARLY
Scythian
RAMRI AND CHEDUBA I SSTS AND SHS
TURBIDITES
OLISTOSTROMES
SLUMPS
TURBIDITES
KENNEDY SST
CHUNSUNG MUDSTONE-TURBIDITE FM
FALAM MUDSTONE-MICRITE FM
TRIASSIC THRUST SHEET
PAUNGGYI CONGLOMERATE
SIN CHAUNG EXOTICS
SERPENTINITE SILLS
PAUNG CHAUNG LST.
PILLOW LAVAS
× SERPENTINITES
METAMORPHISM
PANE CH. GP
KANPETLET SCHISTS
THRUST OVER WESTERN BELT
IRRAWAD
SERIE
PEGU G
YAW SHA
PONDAUNG
TABYIN CL
TILIN· S
LAUNGSHE
PAUNGG
CONGLOM
PAUNG CHAU
PALAEONTOLOGICAL AGE →
K/A-RADIOMETRIC AGE ×

Table 2. Stratigraphic Correlations

...H STAGE	INDOBURMAN RANGES: WESTERN BELT – ARAKAN	INDOBURMAN RANGES: WESTERN BELT – CHIN HILLS	INDOBURMAN RANGES: EASTERN BELT	CENTRAL LOWLANDS: WESTERN TROUGH	CENTRAL LOWLANDS: VOLCANIC ARC (NORTH)	CENTRAL LOWLANDS: VOLCANIC ARC (CENTRAL)	CENTRAL LOWLANDS: EASTE...
				IRRAWADDIAN SERIES	SADWIN FM	SONTAUNG BASALT AND KANTHIT GRAVELS (QUATERNARY)	IRRA... SE...
	→ RAMRI AND CHEDUBA I SSTS AND SHS			→ PEGU GP →	SUNBAUK TAUNG FM GWEGON FM WABO CH. FM (WESTERN MU GP)	SINTAGA FM	PE...
					× AUKTHITAYA TRACHYTE	SHIN MATAUNG FM	
	TURBIDITES			→ YAW SHALES → PONDAUNG SST	× GRANODIORITE		
		KENNEDY SST	TRIASSIC THRUST SHEET	→ TABYIN CLAYS → TILIN SST		ANDESITIC SILLS	
	→ OLISTOSTROMES SLUMPS TURBIDITES	CHUNSUNG MUDSTONE-TURBIDITE FM →	PAUNGGYI CONGLOMERATE →	→ LAUNGSHE SHALES → PAUNGGYI CONGLOMERATE	KETPANDA FM KANGON FM (MANSI GALE GP)	INGYINTAUNG TUFF AND CONGLOMERATE	
...ion ...n	→	→ FALAM MUDSTONE-MICRITE FM	→ SIN CHAUNG EXOTICS	→	NANKOLON CH. FM NAMAKAUK LST (KONDAN CHAUNG GP)		
...an			SERPENTINITE SILLS			× GRANITE × DIORITE × GABBRO	
			→ PAUNG CHAUNG LST.	→ PAUNG CHAUNG LST	× GRANODIORITE		
					MAWLIN FM MAINGTHON DACITE	TAUNGNI BASALT	
					MAWGYI ANDESITE ?	SALINGYI AMPHIBOLITE SCHIST	
Rhaetic Norian Carnian			PILLOW LAVAS × SERPENTINITES METAMORPHISM		SHWEDAUNG FM ?		
Ladinian Anisian			→ PANE CH. GP KANPETLET SCHISTS		HPYU TAUNG METAMORPHICS	TAWGYAUNG GNEISS	
Scythian			THRUST OVER WESTERN BELT				

...EONTOLOGICAL AGE →

RADIOMETRIC AGE ×


S
EASTERN HIGHLANDS
ARC
CENTRAL)
EASTERN TROUGH
S. SHAN STATES
N. SHAN STATES
UNG BASALT AND
HIT GRAVELS
ATERNARY)
IRRAWADDIAN SERIES
LOCAL LACUSTRINE AND FLUVIAL SEDIMENTS
INTAGA FM
PEGU GP
× GRANITES,
× METAMORPHISM
ATAUNG FM
SITIC SILLS
INTAUNG
FF AND
GLOMERATE
KALAW CONGLOMERATE
KALAW RED BED GP
NAMYAU RED BEDS
TELU LIMESTONE
ANITE
ORITE
BBRO
PATCHAUNG VOLCANICS
AUNGNI
ASALT
GRANITES
GYI
BOLITE
T
PAN LAUNG GP
NAMYAU LST
? METAMORPHISM ?
NAPENG BEDS
PANGNO EVAPORITES
GYAUNG
NEISS
? METAMORPHISM ?
NATTEIK LST
NWABANGYI DOLOMITE FM.
SHAN DOL GP
SHAN DOLOMITE GP
THITSIPIN LST
MERGUI GROUP
LATE
EARLY
PLIOCENE
LATE
MIDDLE
EARLY
MIOCENE
LATE
EARLY
OLIGOCENE
LATE
MIDDLE
EARLY
EOCENE
LATE
EARLY
PALAEOCENE
SENO-NIAN
Maastrictian
Campanian
Santonian
Coniacian
Turonian
Cenomanian
Albian
Aption
Barremian
NEOCO-MIAN
LATE
EARLY
CRETACEOUS
LATE
MIDDLE
EARLY
JURASSIC
LATE
Rhaetic
Norian
Carnian
MIDDLE
Ladinian
Anisian
EARLY
Scythian
TRIASSIC
LATE
EARLY
PERMIAN
CARBONIFEROUS

V. STRATIGRAPHY OF THE POST-BASEMENT ROCKS

A. Ingintaung Formation

The oldest stratified rock unit in the area consists largely of conglomerates and tuffs occupying north-trending low hills and ridges in the west of the Shinmataung Hills; it is named from the hill of Ingintaung (1,147 ft) to the west of Shinmataung on which it is well exposed. Conglomerates surrounding gneiss in the north of the Salingyi Uplands are provisionally included in the Formation.

The predominant lithology in the type-area comprises conglomerates and boulder beds mostly dipping at 20° to 30°. They are well-sorted polymict ortho-conglomerates with clasts up to 50 cm diameter in a sandy or gritty matrix. The pebbles and boulders are of black biotite schist, biotite-garnet schist, quartzite, andesitic tuff, vein quartz, diorite or hornblende gabbro, dacitic rock, black chert, amphibolite, jasper, and rare gneiss and pegmatite; most are well-rounded but some pebbles of dacitic rock and vein quartz are sub-angular. The conglomerates are well exposed in only a few localities, mostly in cart tracks, but residual boulders occupy wide areas overlying weathered conglomerates with a thin soil cover.

Grey to cream-coloured andesitic tuffs and agglomeratic rocks and tuffaceous sandstones are interbedded with the conglomerates and occur as clasts within them. The tuffs form steep-sided ridges, for example immediately north of the Sontaung Basalt (0/2 440 160). Bedding is mostly indistinct and angular, often flattened white to buff-weathering lithic fragments of kaolinised felspar or fine-grained tuff up to 5 cm in length are scattered in a fine-grained to sandy matrix.

Rhyolitic lava flows with phenocrysts of quartz and felspar and rarely biotite in a pale green aphantic groundmass occur at one locality (0/2 436 176) and are evidently interbedded with the tuffs.

In the Salingyi Uplands conglomerates occupy a low-lying area of about 3 sq km, surrounding the Tawgyaung gneiss and adjacent to the Kyaunggon diorite. Clasts are mostly of vein quartz but include pebbles and boulders of diorite. Bedding was not observed due to poor exposure.

In the Shinmataung area the Formation overlies the Taungni basalt and diorite with an inferred angular unconformity. It is overlain in the northeast by the Shinmataung Formation and in the west by the conglomerates, sandstones and shales of the Tachanbe Beds. The conglomerates of the Ingintaung Formation can possibly be correlated with the Paunggyi Conglomerate Formation of the eastern foothills of the Chin Hills, 120 km to the west, and with the Ketpanda Formation on the western flank of the Kanzachaung Batholith, 280 km to the north (Table 2). If the correlation with Paunggyi Conglomerates is valid the Ingintaung Formation is of Upper Cretaceous to Lower Eocene age.

B. Minor intrusions in Ingintaung Formation

Small areas of andesitic rock have been observed within the Ingintaung Formation, for example at 0/3 445 175 and at 444 150, where it occurs as areas of igneous boulders within the broader area of heterogeneous boulders which are residuals from the underlying weathered conglomerates. Narrow easterly-trending ridges visible on air photographs within the Ingintaung Formation are probably related to small, poorly exposed igneous bodies. The rock is distinct from the Taungni basalt and characteristically is strongly porphyritic with phenocrysts of plagioclase and hornblende with rare quartz in a pale grey fine-grained groundmass.

The andesite can be interpreted as dykes or sills and possibly flows within the Formation.

C. Shinmataung Formation

Most of the Shinmataung Uplands are occupied by a succession of gently folded clastic sediments with a predominantly red colour occupying a NNW-trending belt. This succession is here termed the Shinmataung Formation from the highest peak in the area, at 1,723 ft. The Formation can be divided into four informal lithological units, which are described below in probable upward stratigraphic sequence.

1. Thayetpingan sandstone and shale

This is considered to be the lowest unit of the Formation, lying in a belt south of, and dipping northwards beneath, the Shinmataung red beds. The unit occupies low hills and undulating lowlands to the south of the Shinmataung hills on 84 0/2 and extends southwards into the north of 84 0/3. The boundaries of the unit are well-defined on air photographs. It is named from the stream section one kilometre east of Thayetpingan village.

In the type-area the Thayetpingan unit consists entirely of sandstone and shale. The sandstone is mostly fine-grained greenish-grey in colour and well-lithified. It varies from massive to strongly cross-bedded and includes local calcareous concretions. Interbedded thin siltstones and shales are commonly grey to brown with parallel or cross-lamination.

Elsewhere, and particularly north of the Salingyi Complex, most outcrops showing a stratigraphic thickness of at least a few metres can be grouped into one or more of a number of distinct sedimentary facies, the stratigraphic relationships among which are uncertain. Three of the most common and distinctive facies, each having a maximum thickness of at least 10 m, are ripple cross-laminated sandstone-mudstone alternations (Plate 2, p. 28), thin parallel-bedded sandstones, and massive to strongly cross-bedded and concretionary thick sandstones. The thick sandstones form topographic ridges up to 2 m elevation but can rarely be traced laterally for more than 200 m. They are mostly grey in colour and include conglomerates with intraformational clasts of mudstone and laminated sandstones (Plate 3, p. 28) interbedded with massive and cross-bedded sandstones.

2. Suyittaung sandstone

This unit lies in angular unconformity on the Taungni basalt and west of a NNW-trending fault in the northwestern part of the Uplands. It consists of red and white quartzose cross-bedded sandstone with minor interbedded shales dipping gently northeastwards. North of the type-area sandstones are mostly white and locally contain a kaolinised matrix; white to purple siltstones are interbedded with the sandstone.

The unit shows some similarities in lithology to the Shinmataung Red Beds east of the fault, but because it lies unconformably on Taungni basalt it is unlikely to be equivalent to the Shinmataung red sandstone unless there is an unconformity at the base of the latter unit. It is therefore provisionally defined as a distinct unit, possibly lying beneath the Taunggya shale and exposed by uplift along the NNW-trending fault.

3. Taunggya shale

A unit of shale and thin sandstones forms a distinctive topographic feature occupying the NE-trending valley which includes the village of Taunggya. It comprises white to buff-coloured siltstones and shales with interbedded thin rippled and cross-laminated sandstones, commonly red in colour and rarely more than 2 cm thick. Near the centre of the valley dips vary gently, but towards the northwestern and southeastern margins they increase to 20° to 30° and the shales and thin sandstones pass up transitionally with the appearance of interbedded thick red sandstones into the topographically higher Shinmataung red sandstone. The Taunggya shale therefore clearly forms an inlier within the surrounding red sandstone.

4. Shinmataung red sandstone

This unit occupies the highest hills in the Shinmataung Uplands and is the most extensive lithological unit of the Shinmataung Formation. It consists largely of red and rarely buff-coloured, mostly cross-bedded sandstones which in the lower part of the unit are interbedded with shales but which increase in proportion and thickness upwards. Locally sandstone units up to 10 m thick form steep scarp slopes broken by benches occupied by shales and thin sandstones above a further thick sandstone. Conglomerates with pebbles of quartz, quartzite and rarely volcanic rock occur locally, for example in the stream bed one kilometre northeast of Taunggya village.

The unit is gently folded mostly about E or NE-trending axes. It has a maximum exposed thickness of rather more than 400 m in the western slope of Shinmataung Taung.

5. Stratigraphic relations and age

Red sandstones of the Suyittaung sandstone lie unconformably on the Taungni basalt in the south slope of Taungni Hill, and the unit also lies in inferred unconformity on the Ingintaung Formation to the west. The Shinmataung red sandstone is overlain unconformably by the Sintaga Formation in the east. The Shinmataung Formation is therefore clearly pre-Miocene in age, and if the Ingintaung Formation is Upper Cretaceous to Lower Eocene, the Shinmataung Formation must lie in the age range Upper Eocene to Oligocene, possibly forming a basal unit of the Pegu Group.

A sample of buff sandstone from near the probable base of the Shinmataung Red Sandstone (0/2 440 196) yielded large gastropods Ampullinopsis birmanica (Vredenburg) superfamily Naticacea, internal moulds of Turritella sp. indet, and bivalves. The Ampullinopsis birmanica was described from the Shinmataung area by Vredenburg (1922) who noted its occurrence in the Shwezetaw Stage of what is now the Pegu Group. The Shwezetaw Stage can be regarded as Early Oligocene, and hence the Shinmataung red sandstone is at least partly of Early Oligocene age (Nuttall, 1978).

The Shinmataung red sandstone is unusual in forming the only red beds described from the very extensive Pegu Group in the Western Trough of Burma.

D. Sintaga Formation

The Sintaga Formation forms an extensive unit east of the Shinmataung Range where it occupies gently undulating lowlands. It is well exposed on the cart track 2.5 km south of Sintaga Village. Dips are mostly easterly and the Formation has an estimated stratigraphic thickness of 900 m.

The predominant lithology is siltstone and sandstone (Plate 4, p. 29) with gritty and concretionary sandstones becoming abundant in the upper part of the unit. Minor lenses and layers of gypsum are interbedded with the siltstone but these are inferred to be recent precipitates. The unit is not described in detail as it has been investigated intensively in recent years by the Myanma Oil Corporation and, in the area to the south, by combined Colombo Plan-DGSE mapping teams in 1977-78.

The Sintaga Formation lies unconformably on the Shinmataung Formation and is overlain by the Kanthit gravels. It has been correlated with the Obogon Alterations of the Pegu Group in the Minbu Basin (Lepper, 1933), which include a shallow marine fauna of Middle Miocene age.

The Tachanbe Conglomerate: A unit of shales and thin pebbly conglomerates extends northwards from near Tachanbe Village on the eastern flank of the Shinmataung Hills. It lies in angular unconformity on the Ingintaung Formation and is overlain in the west by alluvium. From its stratigraphic position and lithology the Tachanbe Conglomerate is provisionally considered to be a local conglomeratic unit within the lower part of the Sintaga Formation.

E. Kanthit gravels

The Kanthit gravels comprise the most extensive stratigraphic unit in the area, forming the succession of poorly consolidated rocks above the Sintaga Formation and beneath alluvium. The gravels are well exposed in the stream cliff section near Kanthit Village (0/2 583 220).

The formation comprises sub-horizontal to gently dipping weakly lithified white quartzose and arkosic sandstone and quartz pebble sandstones and conglomerates. Large calcareous ferruginous and possibly silicic concretions are common, forming cylindrical bodies up to 150 m in length and 50 cm in diameter, smaller interlocking rod-like bodies, and irregular masses. These probably resulted from precipitation around rootlets of salt from groundwater carried upwards by capillary action during seasonal high evaporation.

Soft red and yellow siltstones are interbedded with the sandstones. Silicified wood fragments are abundant in the pebbly sandstones.

Recent silicification is indicated by the presence of silicified tree trunks with axe marks lying on the surface of the gravels (Plate 5, p. 29).

The gravels lie in probable unconformity on the older units in the area although the position of the unconformity cannot easily be defined. They are considered to be equivalent to the Irrawaddy Series of probable Pliocene age.

F. Sontaung basalt

Fresh unaltered basalt occurs at two localities within the area.

The main area of basalt forms the steep-sided flat-topped hill locally known as Sontaung with an area of nearly 5 sq km, in the east of the Shinmataung Hills. It is a well-exposed, jointed to massive, fresh, black basalt showing surface textures typical of sub-aerial blocky lava flows (Plate 6, p. 29). Individual lava flows are clearly visible on 1:20,000 scale air photographs. Hand specimens and thin sections show plagiophyric olivine-bearing basalt and plagiophyric hornblende-bearing basalt with minor altered mafics possibly after hornblende.

The basalt is clearly younger than the Ingintaung and Shinmataung Formations. The relationship of the basalt to the adjacent Kanthit gravels is uncertain. The fresh nature and well preserved surface, and the flow patterns of the lava at Sontaung Hill, suggest that it was erupted on the surface of the Kanthit gravels in the Late Quaternary.

A small basalt body is exposed (0/1 427 527) near the village of Linzagyet; field relationships indicate that it is probably either a sill or flow within the Kanthit gravels. Similarities in lithology suggest an age comparable to that of the Sontaung basalt.

VI. STRUCTURE

Major folds and faults are apparent only in the rocks of Oligocene and younger age, because older rocks occupy very limited areas.

Regionally the Salingyi and Shinmataung Uplands lie on a discontinuous north-trending ridge forming a segment of the Burma Volcanic Arc. The several unconformities in the Shinmataung area indicate that uplift has occurred at intervals since the Late Cretaceous, with the last major elevation occurring after deposition of the Sintaga Formation in the Miocene.

The Salingyi Complex is a broad domal area from which Oligocene to Miocene sediments dip gently to the south, west and north. The Shinmataung Uplands occupy the eastern limb of a NNW-trending anticline with the oldest rocks along the anticlinal axis in the west. The western limb of the anticline is clearly downfaulted, although the actual fault line is obscured by the Kanthit gravels.

In the southern part of the Shinmataung Formation, the oldest unit in which fold axes are recognizable, a number of east-trending minor synclines are present. However, the distribution of the rock units in the Shinmataung area is determined largely by their position on the eastern limb of the NNW-trending anticline.

Faults have been recognized only in the Shinmataung Uplands, where two main trends are apparent on air photographs. NE-trending faults are most abundant, affecting the upper and lower boundaries of the Sintaga and Shinmataung Formations, and locally intersecting the Ingintaung Formation. The displacement of these faults is mostly a few tens of metres, although a fault of larger throw forms the southern boundary of the Shinmataung Formation.

A NNW-trending fault system extends through the western margin of the Shinmataung Uplands, adjacent to the core of the anticline. Although most faults are visible only on air photographs, in a few places juxtaposition of different rock units is visible in the field (e.g., 0/2 452 163). Faults parallel to those of NNW-trend may lie to the west, buried beneath the Kanthit gravels; movement along these has evidently resulted in the downthrow of the western limb of the anticline; at least part of this movement preceded deposition of the Kanthit gravels.

The location of the Sontaung basalt in the zone of NNW-trending faults suggests that its eruption was fault-controlled. The basalt near Linzagyet, 23 km to the north, possibly lies on the same fault line although no linear feature is visible in the intervening Kanthit gravels.

VII. GEOCHEMISTRY AND MINERALIZATION

A. Geochemistry

1. Introduction

The main objective of geochemical reconnaissance in the Salingyi-Shinmataung area was the delineation of possible follow-up targets. The area is situated south of the porphyry copper deposits at Monywa, and from the exploration point of view the Shinmataung igneous rocks and Salingyi Complex were the only areas of interest.

A total of 691 stream sediment samples were collected over the 1,900 sq km of the area, giving an average density of approximately one sample per 2.9 sq km. The sampling density in the two more interesting zones (Salingyi Complex and part of Shinmataung Uplands) was actually higher because the Chindwin and Irrawaddy alluvial valley and river channels, occupying nearly half the area, were not sampled.

The soil cover in the area is residual on the uplands (Salingyi Complex and Shinmataung Basement) and transported in broad valleys draining to the Chindwin and Irrawaddy Rivers.

The samples were routinely analysed for copper, le zinc and silver. The sampling proce es and analytical methods are described in Technical Reports Nos. 2 and 6.

The location of samples and values of anomalous samples are shown on Map 2.

2. Statistical treatment of geochemical data

Copper, lead and zinc results were subjected to a simplified graphical statistical treatment using the method described by Lepeltier (1969). The cumulative frequency curves of Cu, Pb and Zn are shown on Fig. 5. As background value of population, 50 per cent on the cumulative frequency distribution (c.f.d.) curve was accepted. The threshold value was set for all three elements at 2.5 per cent level on the c.f.d. curves.

3. Interpretation of data

(a) Copper:

The background (6.1 ppm) as well as threshold (29 ppm) values are extremely low. A few values exceeding threshold (Fig. 5, Map 2) appear in the Salingyi Complex and scattered in the Shinmataung Red Sandstone area. It is considered that these low absolute values do not indicate the presence of mineralization.

(b) Lead:

Distribution of this element is similar to that of copper. Low background and threshold values (10 ppm and 20 ppm, respectively) close to the detection limit indicate the absence of significant lead mineralization. A few values above threshold occur within the area of the Shinmataung Red Sandstone.

(c) Zinc:

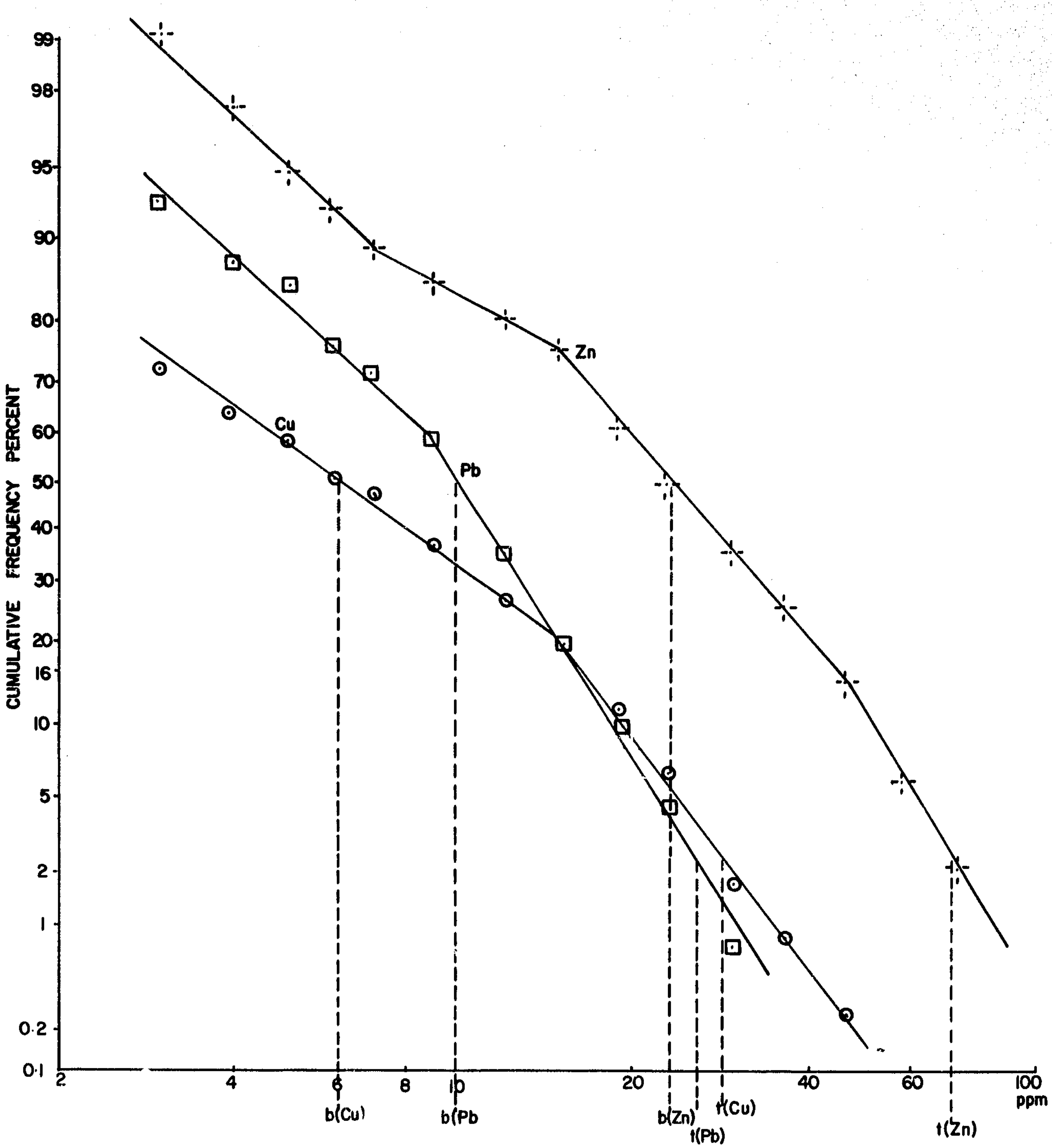
It is correlated with the lead distribution. Altogether 19 values exceeding threshold occur within the area of the Shinmataung Red Sandstone. The highest value (98 ppm) is situated on 0/2 in an area where there is no evidence of mineralization.

4. Conclusions

The stream sediment reconnaissance survey revealed no encouraging anomalous zones. The values exceeding threshold probably reflect lithological variations rather than mineral occurrences. Therefore no further detailed work in the area is recommended.

B. Mineralization

Mineralization had not previously been reported within the area, and none was found during the Project activities,



	⊙Cu	⊡Pb	-¦-Zn
Number of Samples	689	689	689
Background Value	6.1 ppm	10 ppm	23ppm
Threshold Value	29 ppm	26 ppm	71ppm
Geometric Deviation	2·71	1·6	1·78
Coefficient of Deviation	0·43	0·2	0·29
Relative Deviation	7·1%	2·04 %	1·3 %

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SALINGYI-SHINMATAUNG AREA
STREAM SEDIMENTS
CUMULATIVE FREQUENCY
Cu - Pb - Zn

Fig. 5

with the exception of rare specks of chalcopyrite in the Mindaw quartz-keratophyre.

The area lies within the Burma Volcanic Arc of Mesozoic and Cenozoic igneous rocks, which to the north contains copper and gold mineralization. Absence of mineralization at Salingyi and Shinmataung is probably due to the extremely limited area of volcanic rocks, the deep erosion level of the Mesozoic igneous rocks which are mostly metamorphosed, and the absence of Cenozoic volcanic rocks with the exception of minor intrusions, tuffs and flows in the Ingintaung Formation, and recent basalt flows.

VIII. GEOLOGICAL HISTORY

Regional metamorphism of sedimentary rocks to form the Tawgyaung gneiss and the boulders of schist and quartzite in the Ingintaung Formation was possibly contemporaneous with metamorphism in the western part of the Shan States, and probably took place in the Early Mesozoic. Eruption and possibly intrusion of basic igneous rocks, and their low-grade regional metamorphism to form the Salingyi amphibolite schist, was followed by eruption and intrusion of the less metamorphosed Taungni basalt, tentatively correlated with the Mawgyi andesite of probable Lower Cretaceous age in the Pinlebu-Banmauk area. Silicic fine-grained rocks, later weakly metamorphosed to form the Mindaw quartz-keratophyre, were intruded into the Salingyi amphibolite.

Intrusion of diorite and gabbro into the Salingyi amphibolite and perhaps of the dioritic and gabbroic rocks into the Taungni basalt probably took place in latest Lower Cretaceous time, immediately following intrusion of the Baingdaung granite and associated aplitic dykes.

Erosion exposing basalt, amphibolite, schist, granite and gneiss was followed by deposition of the conglomerates of the Ingintaung Formation, accompanied by andesitic pyroclastic eruptions and eruption of minor rhyolite, and followed by intrusion of minor andesitic bodies into the Formation. The conglomerates and tuffs are possibly equivalent to the Paunggyi conglomerate of the Western Trough, and hence are of later Upper Cretaceous to Lower Eocene age.

Deposition of the Shinmataung Formation began with a Lower Oligocene transgression across the Ingintaung Formation and Taungni basalt, and included fossiliferous shallow marine sandstones, although the red cross-bedded sandstones characteristic of the Formation are probably a continental facies.

Uplift and erosion, probably in the Oligocene, was followed by deposition of the shallow marine and non-marine Sintaga Formation, part of the extensive Pegu Group, in probable unconformity on the Shinmataung Formation. The Tachanbe conglomerate, considered to be a facies of the lower part of the Sintaga Formation, rests in angular unconformity on the Ingintaung Formation. The main folding episode resulting in the Shinmataung anticline probably took place in the Late Miocene after deposition of the Sintaga Formation.

Deposition of the Kanthit gravels probably accompanied movement along NNW-trending faults, including westward downfaulting of the western limb of the Shinmataung anticline, and was followed by displacements along faults of NE-trend. The position of basalt eruptions of possibly recent age and intrusion of a basaltic neck near Linzagyet were probably controlled by the NNW-trending faults.

Annex I

PROJECT PERSONNEL

A. International personnel

Name and title	Nationality	Arrival date	Departure date
J. V. Huhta Project Manager	Finland	Jan. 1974	June 1978
A. H. G. Mitchell Chief Geologist	United Kingdom	Jan. 1974	July 1978
P. Carrel Economic Geologist	France	Dec. 1974	Oct. 1976
F. Sumi Geophysicist	Yugoslavia	Oct. 1974	Mar. 1978
B. Zitek Chief Geochemist	Czechoslovakia	Feb. 1975	Mar. 1978
T. Davenport Field Geochemist	United Kingdom	Apr. 1975	Feb. 1976
F. Baumann Consultant	Canada	Mar. 1976	July 1976

B. National personnel

U Kyi Soe — Project Co-Director

Geologists

U Zaw Pe
U Danny Sein
U Khin Maung Aye
U Tin Hlaing
U Tin Maung Thein
U Tin Swe
U Kyi Tun
U Soe Thi Ha
U Nyunt Htay
U Nyunt Swe
U Myint Swe
U Khin Maung Aye
U S. Lwin Than
U Ko Ko
U Aye San
U Kyaw Sein
U Tet Sein
U Sein Tun

Geologists (continued)

U Tint Naung
U Kyaing Sein
U Saw Andrew Htwe
U Ohn Maung
U Ye Maung Tin
U Than Aung
U Htein Win
U Htein Lynn
U Tin Than
U Soe Kyi
U Aung Gyi
U Tin Hlaing
U Tin Maung Win
U Shyam
U Sein Aung Win
U Richard Shwe
U Kyaw Win
U Tint

Geologists (continued)

U Myo Myint Swe
U Saw Naung
U Htay Win
U Thein Han
U Ko Ko
U Ba Kyi

Geochemists

U Shwe Gaung Lay
U Kyaw Soe
Daw Khin Khin Win
Daw Thit Thit Hla
Daw Myat Myat Sein

Geophysicists

U Tin Myint Oo
U Win Myint
U Nyunt Sein
U Tauk Tut
U Thein Htun
U Mya Thaung
U Khin Maung Htay
U Kyaw Soe

Drilling Engineer

U Ba Soe

Draftsmen

U Tun Aye
U Tun Shin
U Khin Pyone
U Tin Wan
U Khin Sein
U Hla Than
U Hla Tun
U Maung Maung Nyo

C. National professional personnel in Salingyi-Shinmataung Area

Chief

U Zaw Pe

Geologists and geochemists

Tin Maung Thein, Htein Lynn, Myint Swe, Myo Myint Swe, Ohn Maung, Maung Tint, Kyaw Sein

Photogeologist

Tin Swe

Chemists

Shwe Gaung Lay, Kyaw Soe, Myint Thein, Cho Cho Myint, Khin Khin Myint, Yan Aung, Khin Khin Lay, San San Yee, Khin Swe Swe, Myint Myint Than, Saw Shalama and Khin Moe Hnin

Annex II

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A. References

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ZAW PE, SAN MYINT, MAUNG TINT, MYO MYINT SWE AND YE MYINT THEIN, 1975. Report on Salingyi Area (unpub.).

B. Project technical reports

1. Geology and mineralization of the Shangalon Copper Prospect and its surroundings.

2. Geology and exploration geochemistry of the Pinlebu-Banmauk Area, Sagaing Division, northern Burma.

3. Geology and exploration geochemistry of the Shan Scarps area east of Kyaukse, Thazi and Tatkon, central Burma.

4. Geology and exploration geochemistry of part of the northern and southern Chin Hills and Arakan Yoma, western Burma.

6. Mineral exploration in selected areas, Burma.

Plate 1

Conglomerate, Ingintaung Formation. Loc. 840/2 442 152.

Plate 2

Ripple cross-laminated sandstone and siltstone, Thayetpingan sandstone and shale, Shinmataung Formation. Loc. 840/1 439 685.

Plate 3

Mudstone-sandstone conglomerate, Thayetpingan sandstone and shale, Shinmataung Formation. Loc. 840/1 438 687.

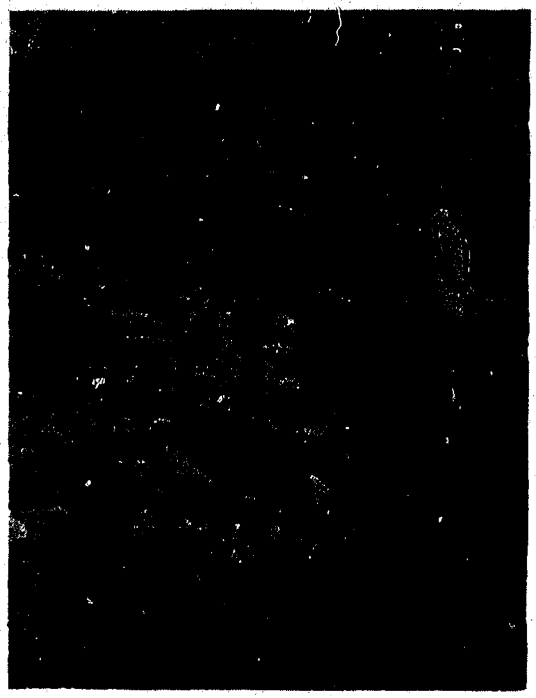


Plate 4

Laminated clay and sandstone, Sintaga Formation. Loc. 840/2 513 215.

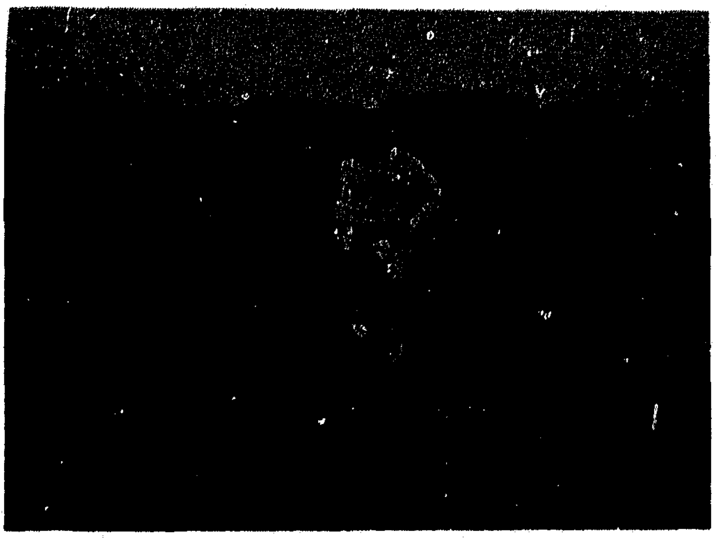


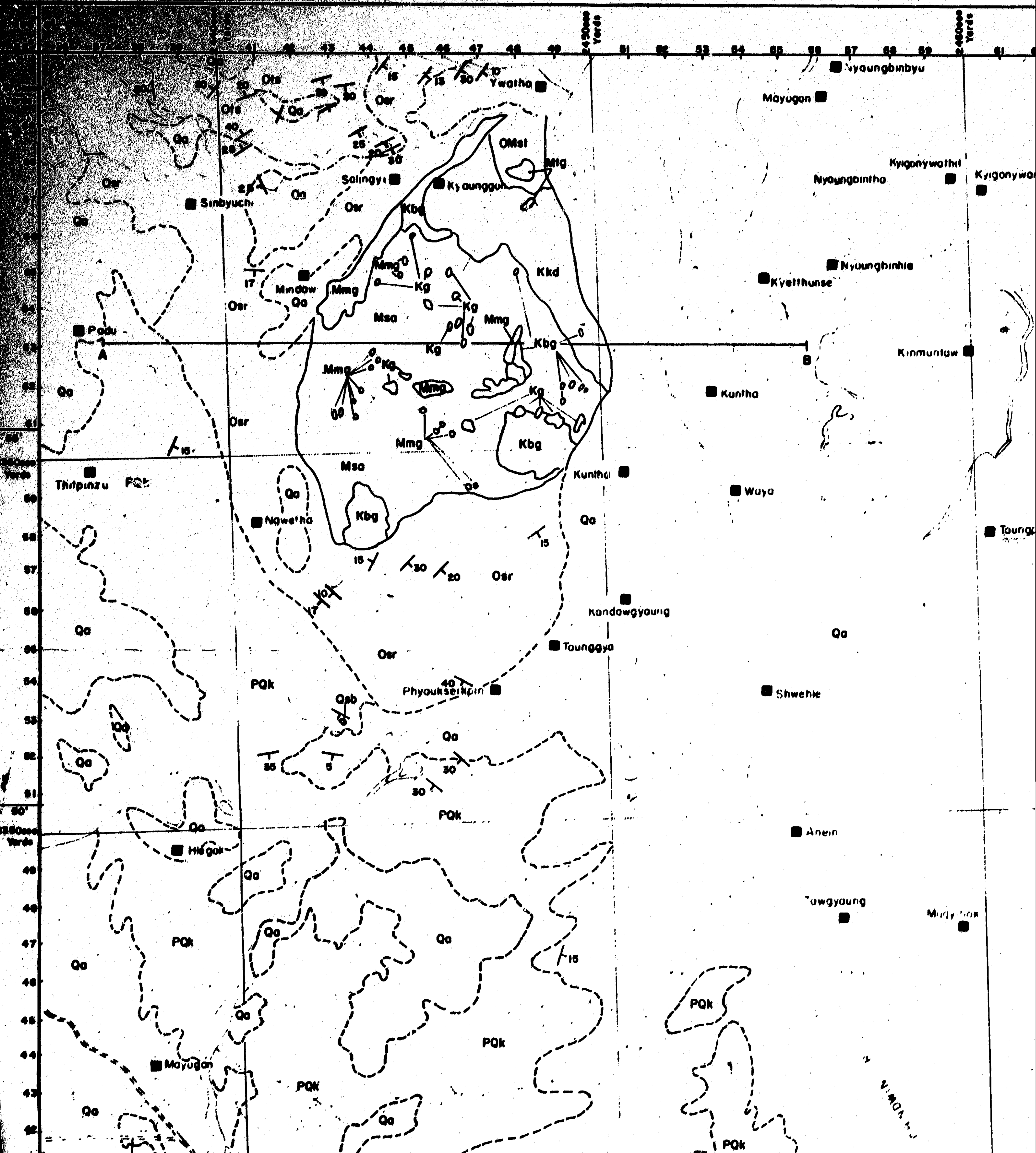
Plate 5

Silicified recent tree trunk lying on Kanthit gravels. Loc. 840/1 419 680.

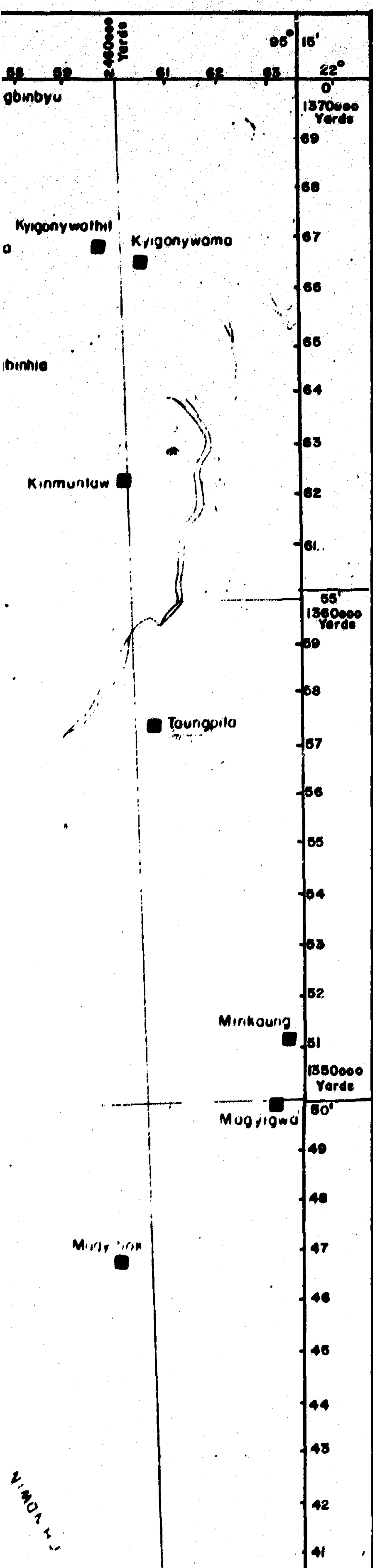
Plate 6

Blocky vesicular lava, surface of flow, Sontaung basalt. Loc. 840/2 450 135.

GEOLOGY OF THE SALINGYI - SHINMATA

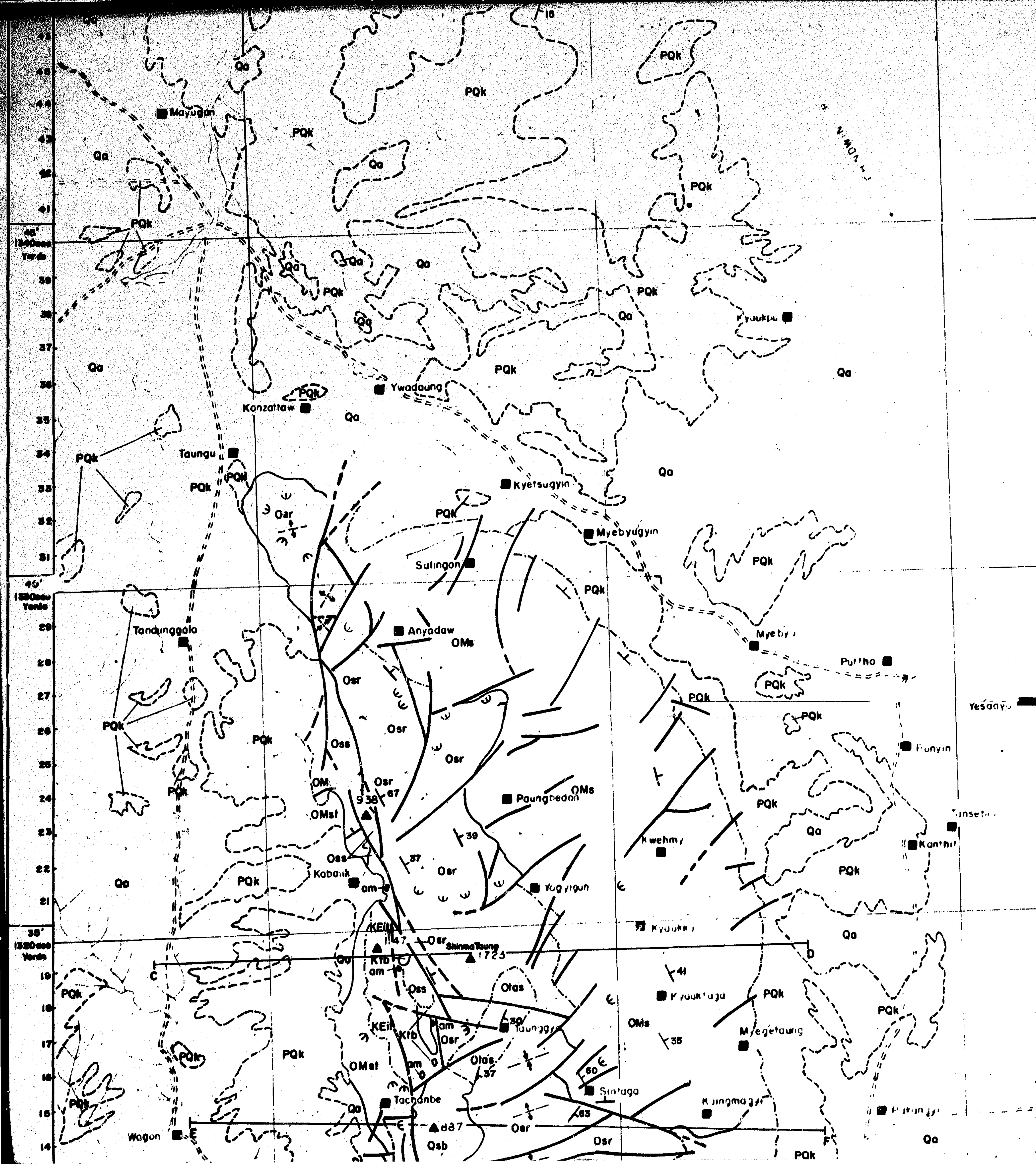


SHINMATAUNG AREA, CENTRAL BURMA



GEOLOGICAL LEGEND

AGE		MEMBER OR UNIT	FORMATION	DESCRIPTION
QUATERNARY	Qa		ALLUVIUM	
	Unconformity			
? QUATERNARY	Qsb		SONTAUNG BASALT	
	Unconformity			
? PLIOCENE – QUATERNARY	PQk		KANTHIT GRAVELS	
	Unconformity			
OLIGO-MIOCENE	OMs oMst	TACHANGE CONGLOMERATE	SINTAGA	
	Unconformity			
LOWER OLIGOCENE	Osr	SHINMATAUNG RED SANDSTONE	SHINMATAUNG FORMATION	
? LOWER OLIGOCENE	Otas	TAUNGGYA SHALE		
	Unconformity			
? LOWER OLIGOCENE	Oss	SUYIT TAUNG SANDSTONE		
? LOWER OLIGOCENE	Ots	THAYETPINGAN SANDSTONE & SHALE		
? EOCENE	am		ANDESITIC MINOR INTRUSIONS	
? UPPER CRETACEOUS TO LOWER EOCENE	KEit		INGYINTAUNG TUFF & CONGLOMERATE	
	Unconformity			
? LOWER CRETACEOUS	Ktb		TAUNGNI BASALT	
		SALINGYI COMPLEX		
? MID – CRETACEOUS	Kap		APLITIC DYKES	
MID – CRETACEOUS	Kbg		BAINGDAUNG GRANITE	



Mayugan
Konzattaw
Ywadaung
Taungu
Kyetsugyin
Myebyugyin
Sulingon
Anyadaw
Tandinggala
Puttho
Yesagyo
Paungbedon
Kwehmy
Kabauk
Yogyigun
Shinma Taung
1723
Taunggyi
Sintaga
Tachanbe
887
Wagun
Kaingmagyi
Myegetaung
Kyaukpu
Tunseto
Kanthit
Ponyin
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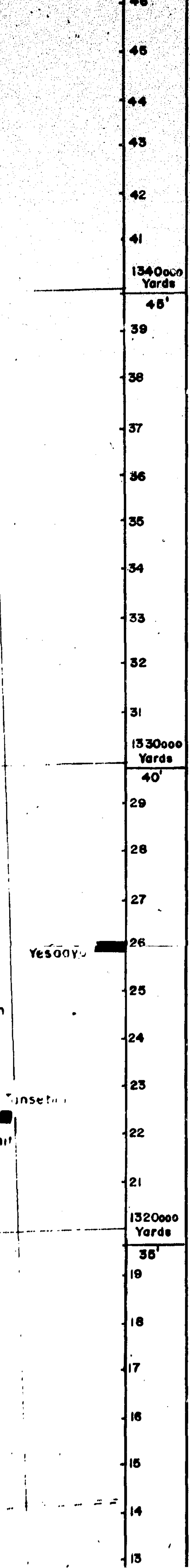


SALINGYI COMPLEX

? MID - CRETACEOUS	Kap	APLITIC DYKES
MID - CRETACEOUS	Kbg	BAINGDAUNG GRANITE
MID - CRETACEOUS	Kkd	KYAUNGGON HORNBLENDE DIORITE
MID - CRETACEOUS	Kg	GABBROIC INTRUSIONS
MID - CRETACEOUS	Mmg	MINDAW QUARTZ-KERATOPHYRE
? PRE - CRETACEOUS	MSa	SALINGYI AMPHIBOLITE SCHIST
PRE - CRETACEOUS	Mtg	TAWGYAUNG GNEISS

GEOLOGICAL SYMBOLS

STRATIGRAPHIC BOUNDARY
- MAPPED
- APPROXIMATE & INFERRED
- PHOTOGEOLOGICAL

DIP AND STRIKE OF BEDDING
- INCLINED
- VERTICAL
- PHOTOGEOLOGICAL

FOLD AXES (PHOTOGEOLOGICAL)
- ANTICLINE
- SYNCLINE

HIGH ANGLE FAULT
- MAPPED & PHOTOGEOLOGICAL
- INFERRED

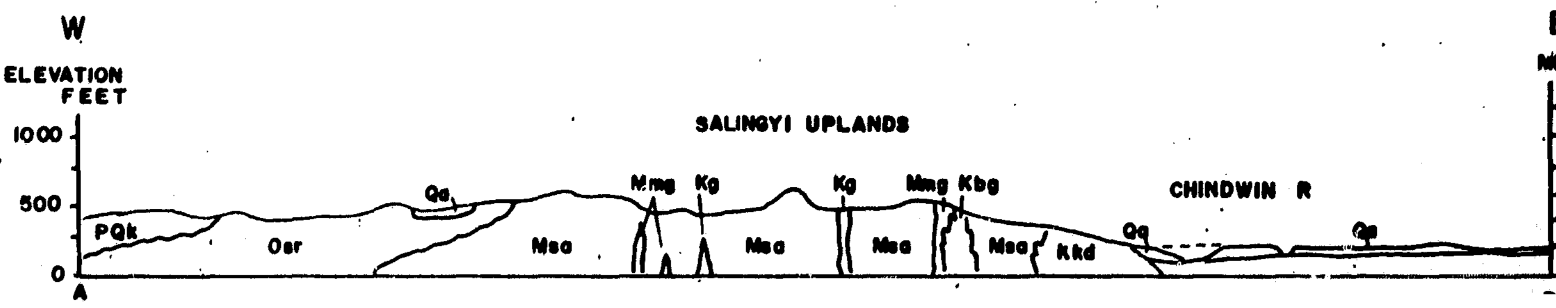
GEOGRAPHICAL SYMBOLS

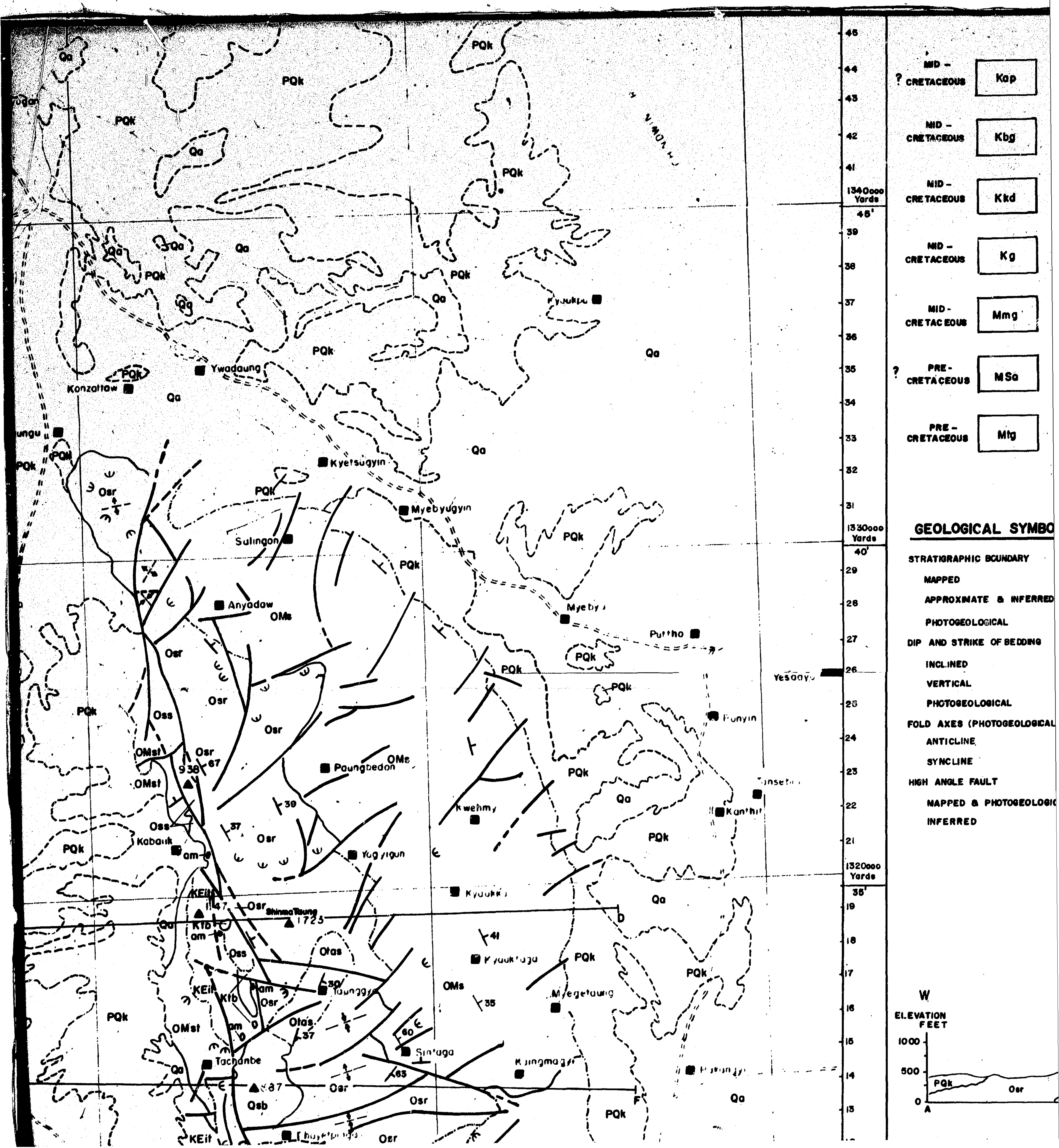
- ALL SEASON MOTOR ROAD
- RIVER
- STREAM
- HEIGHT IN FEET
- VILLAGE

CROSS SECTIONS A-B, C-D AND E-F

SCALE HORIZONTAL 1:100,000

VERTICAL EXAGGERATION X 5 (APPROXIMATE)





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MID - CRETACEOUS Kkd
MID - CRETACEOUS Kg
MID - CRETACEOUS Mmg
? PRE - CRETACEOUS MSa
PRE - CRETACEOUS Mtg
GEOLOGICAL SYMBO
STRATIGRAPHIC BOUNDARY
MAPPED
APPROXIMATE & INFERRED
PHOTOGEOLOGICAL
DIP AND STRIKE OF BEDDING
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VERTICAL
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FOLD AXES (PHOTOGEOLOGICAL
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Paungbedon
Kabauk
Shinma Taung
1725
Taunggya
Tachanbe
Sintuga
Kyaukpu
938
Kwehmy
Kanthit
Myegetaung
PQk
Qa
Osr
Oss
OMs
OMst
KEit
Ktb
Otas
Qsb
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SALINGYI COMPLEX

MID - RETACEOUS	Kap	APLITIC DYKES
MID - RETACEOUS	Kbg	BAINGDAUNG GRANITE
MID - RETACEOUS	Kkd	KYAUNGGON HORNBLENDE DIORITE
MID - RETACEOUS	Kg	GABBROIC INTRUSIONS
MID - RETACEOUS	Mmg	MINDAW QUARTZ-KERATOPHYRE
PRE - RETACEOUS	MSa	SALINGYI AMPHIBOLITE SCHIST
PRE - RETACEOUS	Mtg	TAWGYAUNG GNEISS

GEOLOGICAL SYMBOLS

TRATIGRAPHIC BOUNDARY
- MAPPED
- APPROXIMATE & INFERRED
- PHOTOGEOLOGICAL

IP AND STRIKE OF BEDDING
- INCLINED
- VERTICAL
- PHOTOGEOLOGICAL

OLD AXES (PHOTOGEOLOGICAL)
- ANTICLINE
- SYNCLINE

IGH ANGLE FAULT
- MAPPED & PHOTOGEOLOGICAL
- INFERRED

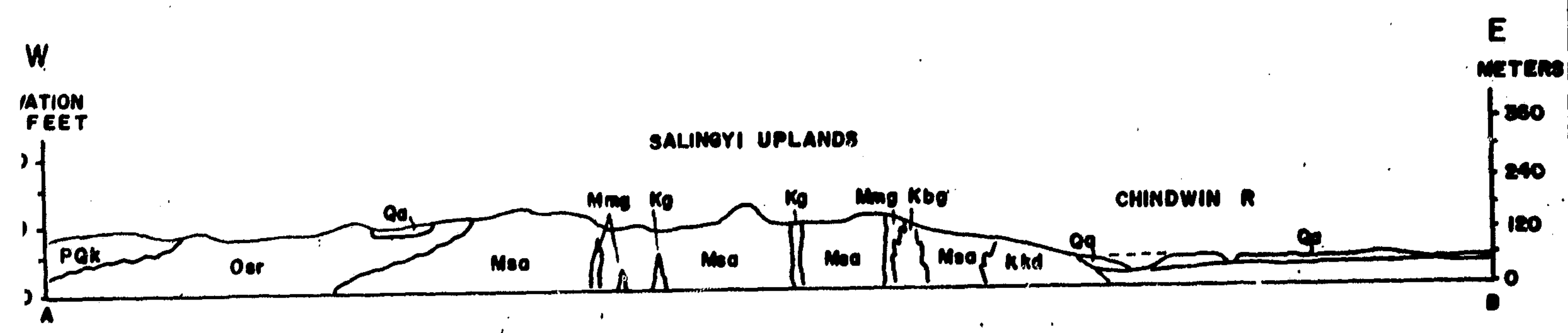
GEOGRAPHICAL SYMBOLS

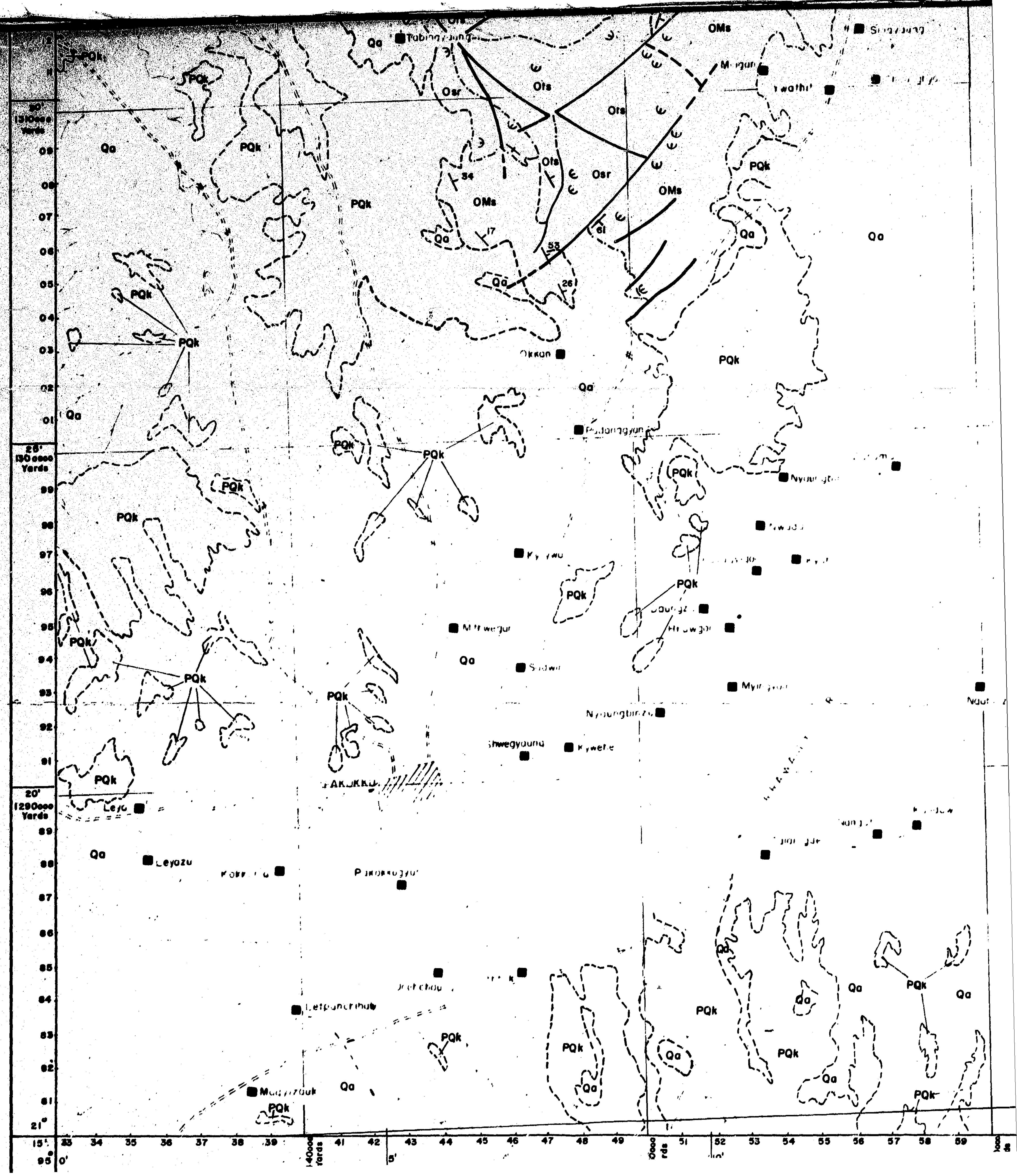
- ALL SEASON MOTOR ROAD
- RIVER
- STREAM
- HEIGHT IN FEET
- VILLAGE

CROSS SECTIONS A-B, C-D AND E-F

SCALE HORIZONTAL 1: 100,000

VERTICAL EXAGGERATION X 5 (APPROXIMATE)

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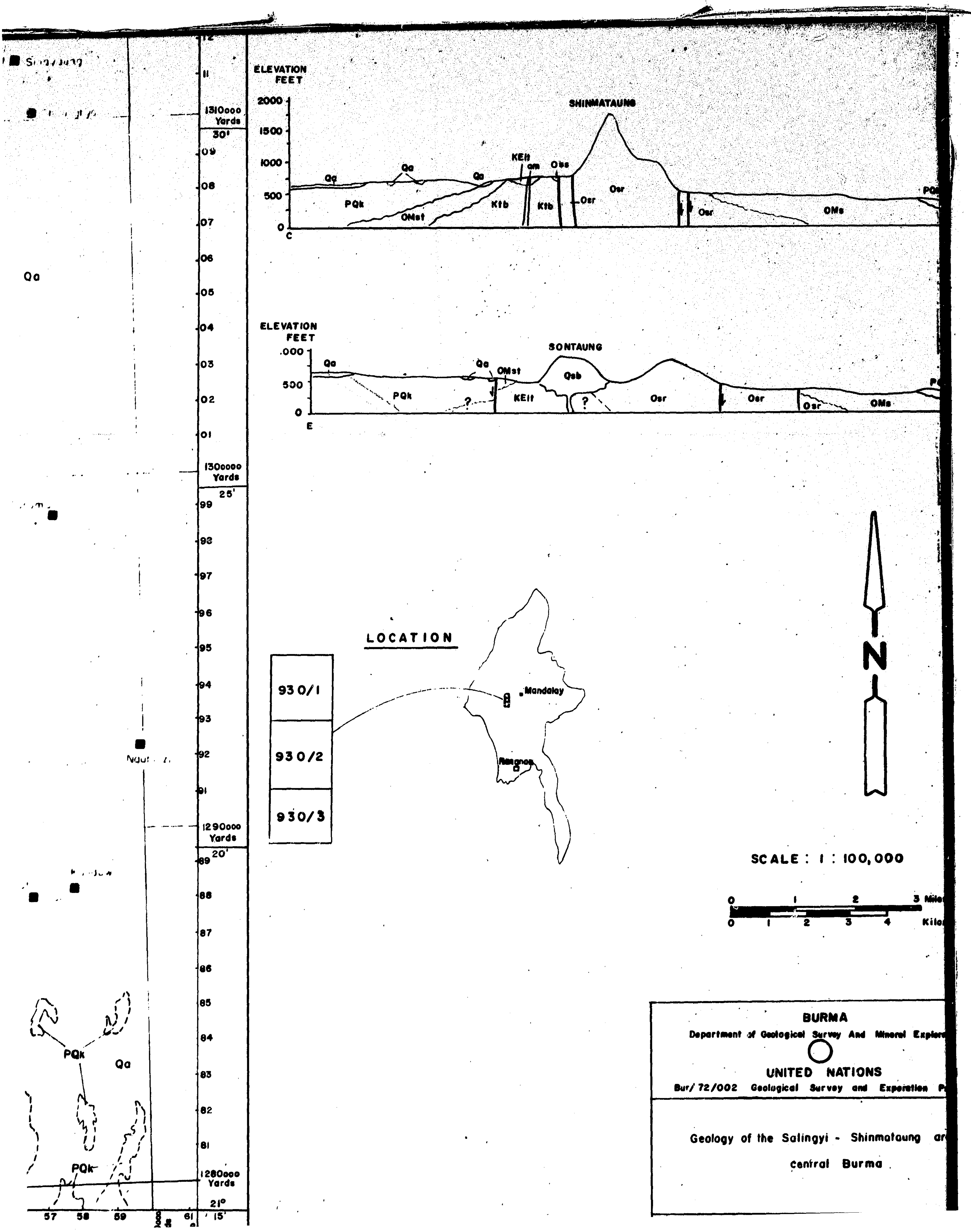

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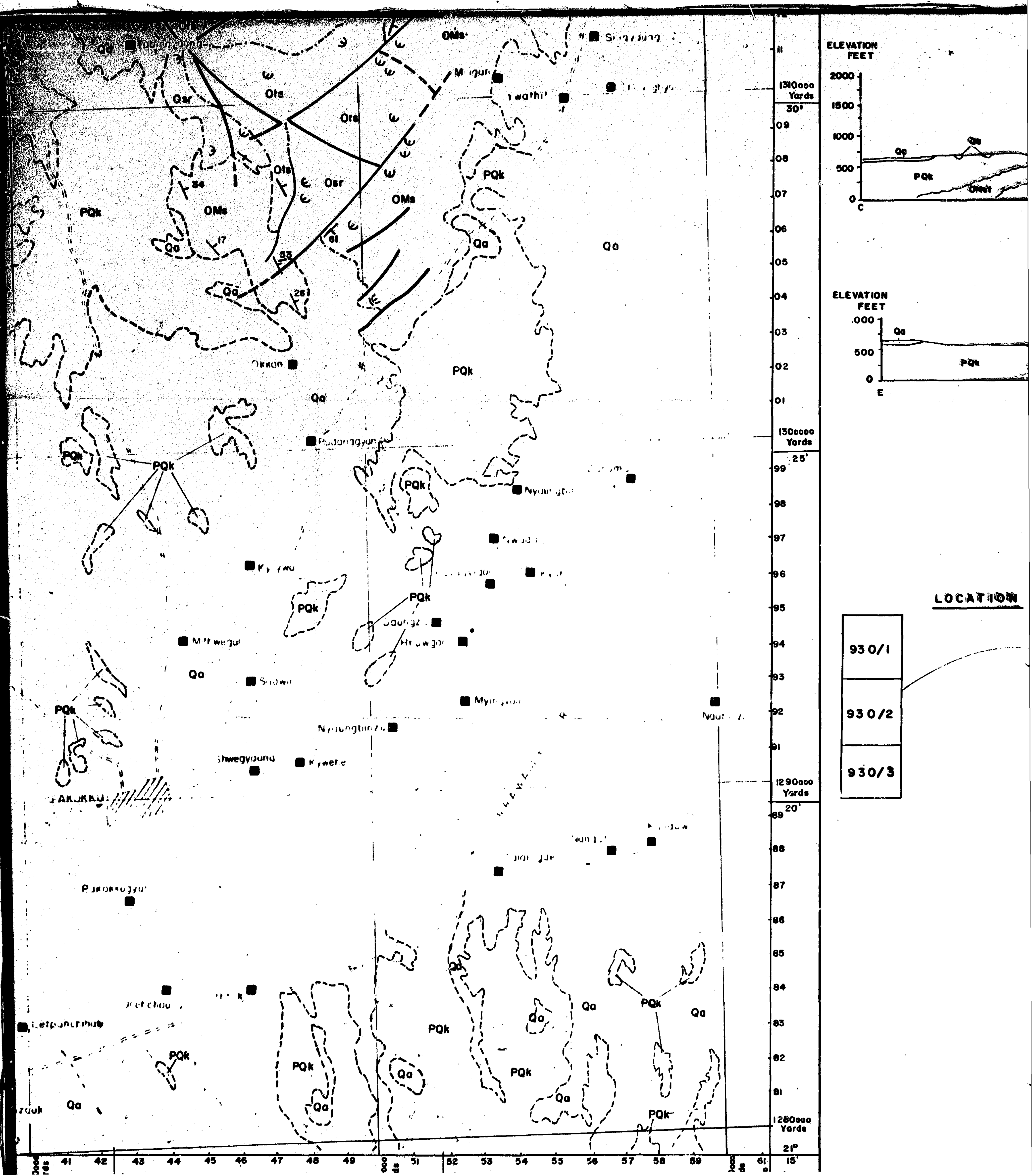

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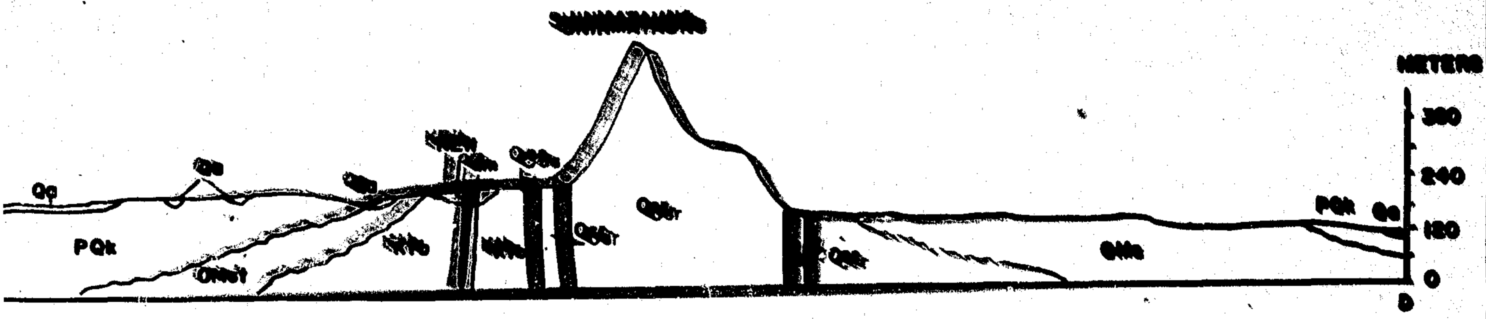

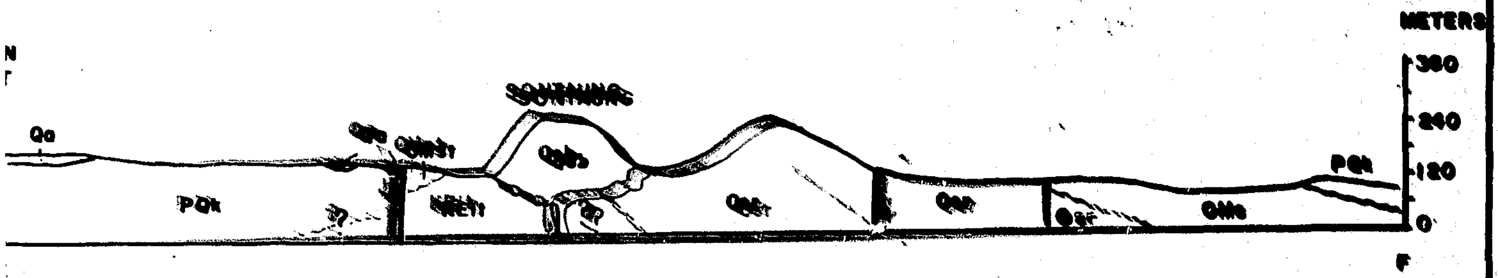

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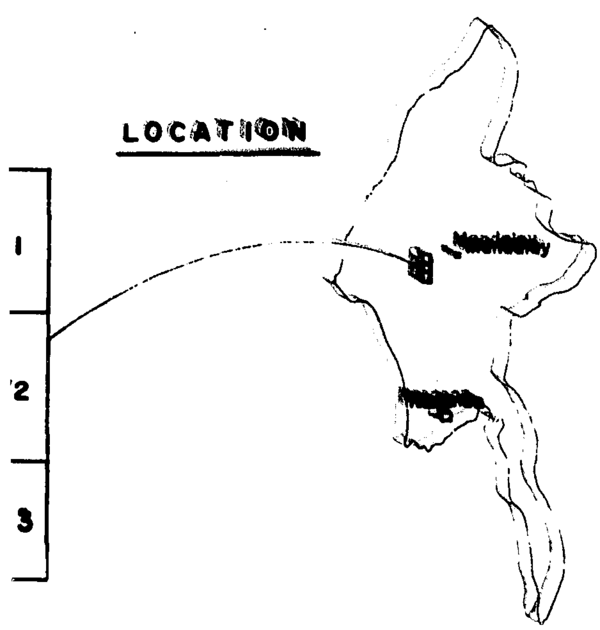

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BURMA

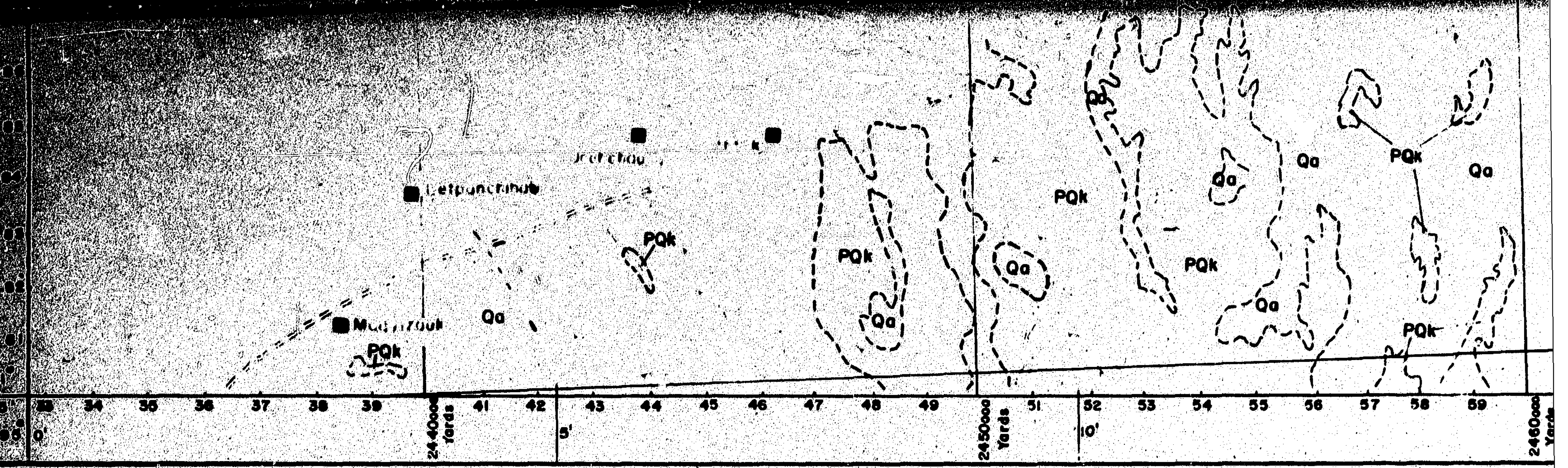
Department of Geological Survey And Mineral Exploration

UNITED NATIONS

Bur/72/002 Geological Survey and Exporation Project.

Geology of the Salingyi - Shinmataung area,

central Burma



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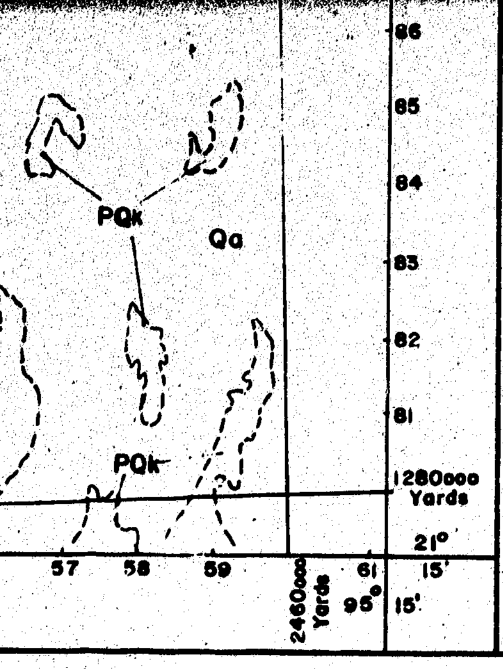

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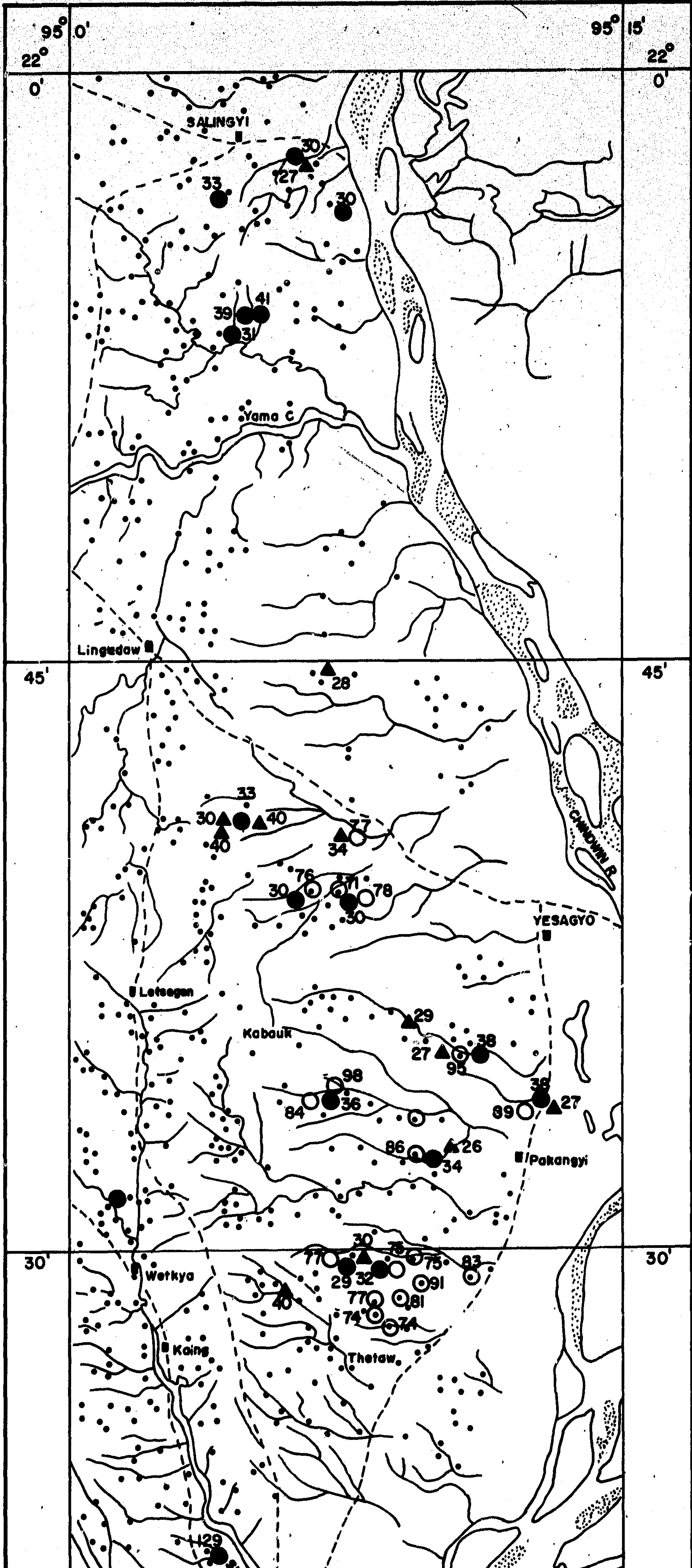
Geology of the Salingyi - Shinmataung area, central Burma

Map. 1



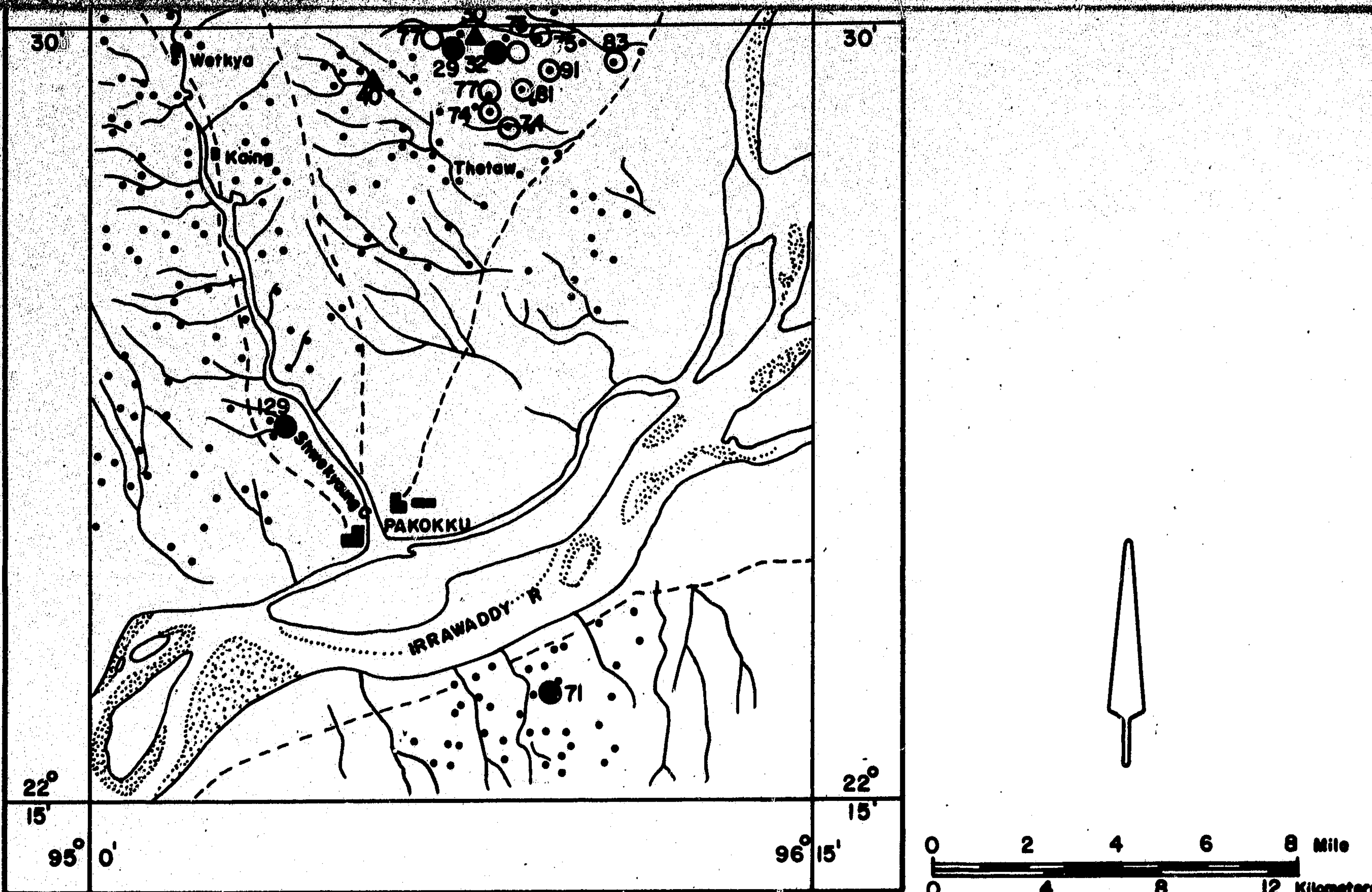
GEOCHEMISTRY

SAMPLING POINT

● Cu VALUE ≥ THRESHOLD = 29 ppm

▲ Pb VALUE ≥ THRESHOLD = 26 ppm

○ Zn VALUE ≥ THRESHOLD = 71 ppm



MAP INDEX

84 J/16	84 N/4	84 N/8
84 K/13	84 O/1	84 O/5
84 K/14	84 O/2	84 O/6
84 K/15	84 O/3	84 O/7
84 K/16	84 O/4	84 O/8

BURMA

Department of Geological Survey and Mineral Exploration

UNITED NATIONS

Bur-72-002 Geological Survey and Exploration Project

SALINGYI- SHINMATAUNG AREA

GEOCHEMICAL RECONNAISSANCE MAP

MAP - 2

UNITED NATIONS NATIONS UNIES

POSTAL ADDRESS--ADRESSE POSTALE UNITED NATIONS, N.Y. 10017
CABLE ADDRESS--ADRESSE TELEGRAPHIQUE UNATIONS NEWYORK

REFERENCE: EC 132/226/2 BURMA (12)

I have the honour to refer to the project "Mineral Exploration (BUR-72-002)" undertaken in Burma with the assistance of the United Nations Development Programme, for which the United Nations serves as executing agency, and to transmit a technical report of the United Nations entitled "Geological mapping and geochemical exploration in Mansi-Manhton, Indaw-Tigyaing, Kyindwe-Longyi, Patchaung-Yane and Yezin areas, Burma", Technical report 7 (DP/UN/BUR-72-002/16).

The report provides the preliminary results of regional geological mapping and reconnaissance geochemical exploration programme carried out in five areas of Burma during the 1977/78 field season. These areas aggregated approximately 6,300 sq. km. and were chosen as a result of previous work carried out by the project, in particular that reported on in Technical reports Nos. 1, 2, 4 and 6.

A total of 2,269 stream sediment geochemical samples were collected though full analytical results were not available at the time of writing the report. It is recommended however, that any anomalous zones indicated by the results should be followed up by more detailed work later.

Examination of mineral occurrences by the project suggests that detailed follow-up of the relative size of a number of tungsten-tin occurrences in the Yezin area should be carried out. Follow-up requirements on other mineral occurrences will depend on the analytical results of the geochemical sampling.

UNITED NATIONS NATIONS UNIES

We should appreciate your informing us, through the Office of the Resident Representative of the United Nations Development Programme, of your Government's comments on the report.

This report represents technical contributions prepared with the co-operation of the United Nations Development Programme. In conformity with the agreement governing such co-operation, the report should be available for utilization by all interested parties. We should, therefore, appreciate your Government's agreement to the derestriction of the report so that it may be placed on open file and made available to all interested parties. Your Government's concurrence to derestriction will be assumed, unless you inform us, within six months of the date of this letter, that you wish the report to remain restricted.

Accept, Sir, the assurances of my highest consideration.

for

Findley Burns, Jr.
Director of Operations
Department of Technical Co-operation
for Development